THIS NUMBER COMPLETES VOLUME XIV

VOLUME XIV NOVEMBER, 1931 NUMBER 6

JOURNAL OF DAIRY SCIENCE

OFFICIAL ORGAN OF THE
AMERICAN DAIRY SCIENCE ASSOCIATION

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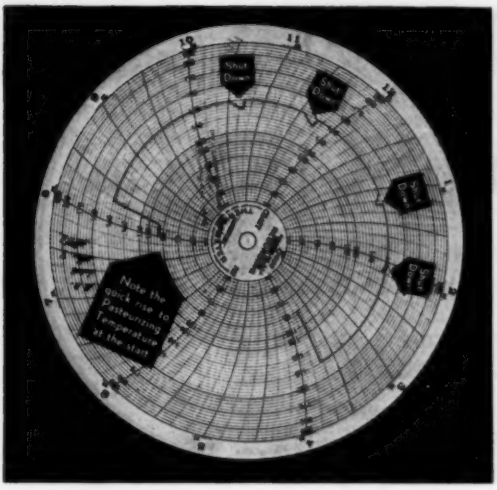

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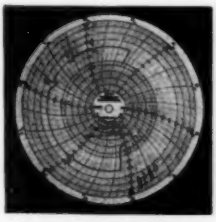

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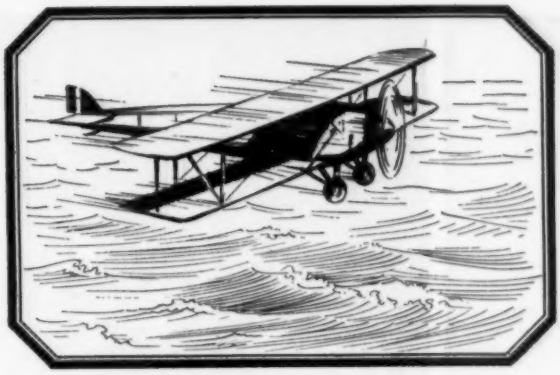

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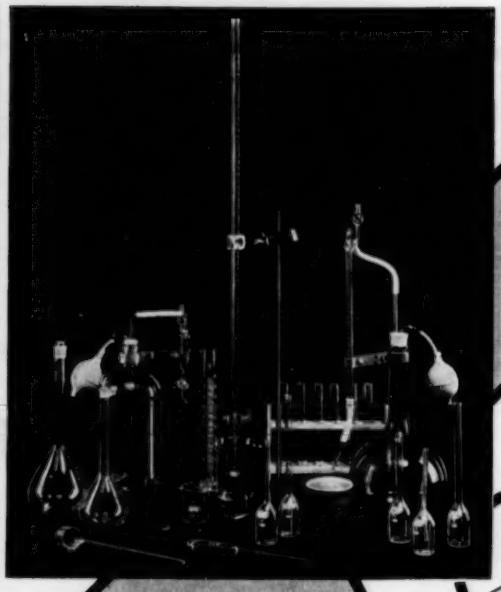

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FURTHER REMARKS ON DATA ON BACTERIAL COUNTS PRESENTED BY BREW AND DOTTERRER AND ANALYZED BY BREW*

G. A. BAKER

Statistician, New York State Department of Health, Albany

Bacterial counts are commonly used by health departments in discriminating against sources of supply of milk for fluid use. It is usual in routine work to use some method of estimating the gross number of bacteria in milk. The number of bacteria, in the same lots of milk, estimated by various methods often varies considerably. Thus it may become of interest to compare the estimates of the number of bacteria in the same lots of milk by two or more different methods.

A comparison of the estimates of the bacteria in raw milk by means of the agar plate method and the direct microscopic method has been made by Brew (1) on the basis of data presented by Brew and Dotterrer (2). It is the purpose of this paper to present a few statistical considerations that were overlooked in the statistical analysis of the data but which serve to strengthen the remarks of Dr. Brew made in the text of his paper and to make a few additional remarks.

The portion of the data of Brew and Dotterrer that is to be discussed here by way of illustration consists of 491[1] comparative bacterial counts by the agar plate method and the direct microscopic method on raw market milk.

The statistical analysis of these data was not sufficient to indicate the true relation between the agar plate and direct micro-

* Received for publication March 23, 1931. Acknowledgments are made to Dr. J. D. Brew, Milk Specialist, New York State Department of Health and to Mr. W. D. Tiedeman, Chief of the Bureau of Milk Sanitation, New York State Department of Health for advice in this presentation.

[1] The first 52, the last 7, and the numbers 131 and 357 of these counts are omittted in this presentation.

scopic methods of counting bacteria. It is not necessary with this particular type of data to consider the whole mass of data at one time and to summarize it into a single set of figures. In this case it is better not to do so because the counts vary over such a tremendous range and the extreme items, in summary figures, entirely mask the relation between the counts in the more interesting portions of the ranges and because the marginal distributions are of doubtful significance where the object is merely to compare two methods. The marginal distributions, when comparisons between the estimates of numbers of bacteria by two different methods are being made, depend upon the arbitrary selection of the person collecting the data. The best comparisons would be obtained if, when the plate counts were being compared with the direct microscopic counts, there was about the same number of plate counts for each sub-interval of the direct microscopic counts. That is, the marginal distribution of the direct microscopic counts would be rectangular. Similarly, if the direct microscopic counts were to be compared with the plate counts on a considerable number of different lots of milk the best comparison would be obtained if the marginal distribution of the plate counts was approximately rectangular. With data that can have any shape of marginal distributions depending upon the choice of the investigator it is better to regard the correlation coefficient and other constants as mere summary figures and not to attempt any statement of the limits of random variations unless the number of observations is large. Any set of data could, perhaps, be regarded as a random sample from some population and if the number of observations was very large, probable errors could be calculated on this basis. If probable errors are given based on ordinary formulae it is necessary to show rigorously that the data approximate both in form and in method of collection the assumptions on which the formulae were derived. The data analyzed by Brew do not sufficiently approximate the ordinary type of data that has been dealt with heretofore to make it apparent that the ordinary expressions for random sampling variations apply when the whole mass of data is considered at once.

A much more enlightening statistical procedure than the one employed by Brew would be to block off a certain interval, say from greater than zero to 100,000 count, for the direct microscopic method and to investigate the locus of the mean values of the bacterial counts by the agar plate method as the direct microscopic counts cover this range. This principle is followed in the accompanying figures.

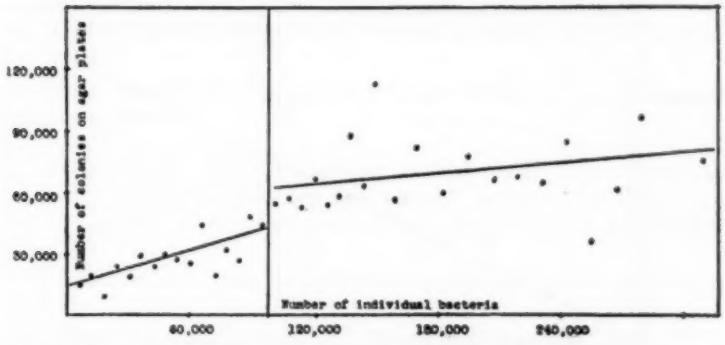

FIG. 1. LOCUS OF MEAN PLATE COUNTS FOR GIVEN DIRECT MICROSCOPIC COUNTS

	Sub-interval I	*Sub-interval II*
Constant (calculated without grouping):		
Mean direct microscopic count	31,500	174,500
Standard deviation direct microscopic count	26,000	53,000
Mean plate count	24,300	68,200
Standard deviation plate count	27,000	49,300
Correlation coefficient	.22	.12
Regression equation	Mean plate count = .23 direct microscopic	Mean plate count = .12 direct microscopic

Figure 1 shows the relation between the number of colonies on agar plates and the number of individual bacteria determined by the direct microscopic method for 209 samples of low count milk and for 100 samples of medium count milk. The dots represent actual observed average plate counts for the designated direct microscopic counts. The sloping lines are the lines that "best" represent the locus of the observed means in each subinterval. If the data were adequate, the locus of the modes or

medians of the distributions of the plate counts for given direct microscopic counts might be of great deal more interest because of the great influence of extreme items on the arithmetic mean. It will be seen for these particular data that when the direct microscopic count is in the interval greater than zero to 96,000 the average plate counts increase about one-fifth as fast as the direct microscopic counts. There is an abrupt rise in the locus

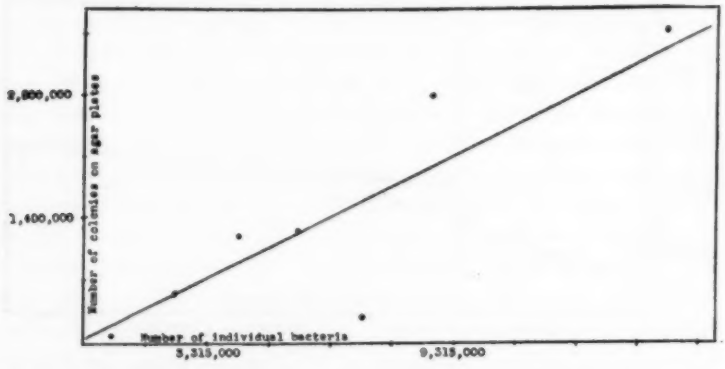

FIG. 2. LOCUS OF MEAN PLATE COUNTS FOR GIVEN DIRECT MICROSCOPIC COUNTS

Constant (calculated without grouping):	
Mean of direct microscopic counts	1,695,000
Standard deviation of microscopic counts	2,042,000
Mean of agar plate counts	424,000
Standard deviation of agar plate counts	722,000
Correlation coefficient	.62
Regression equation	Mean plate count = .22 direct microscopic

of the mean plate counts at a direct microscopic count of about 96,000 and then the locus proceeds almost on a level to a direct microscopic count of 315,000. This means that a knowledge of the direct microscopic count in the latter interval is of almost no value in predicting or estimating the plate count.

Figure 2 shows the relation between the mean number of colonies on agar plates and the number of individual bacteria by the direct microscopic method for 120 samples of high count milk.

The very extreme samples show a much higher association. These 120 items are almost entirely dominated by a few extreme items which would also dominate the whole mass of data if they were included in the summary figures. The inclusion of these extreme items would give a false notion of the degree of association between the two methods. It should be noted that the second figure is drawn to quite different scales than is the first.

The locus of mean direct microscopic counts for given values of the agar plate counts would probably exhibit similar characteristics.

These data are inadequate to warrant definite conclusions, but they suggest:

a. That, if the direct microscopic method really gives an estimate of the number of bacteria, the plate method under-estimates the number of bacteria in almost all milk with a direct microscopic count over 180,000

b. That both methods are subject to considerable errors of estimation, and

c. That it is very desirable to form some notion of the shape and location of the frequency distributions of the errors of estimation of each method as a basis for judging the significance of differences in counts and the adequacy of a certain number of determinations to estimate, within certain limits, the true number of bacteria.

In order to accomplish (*c*) the approach must, necessarily, be empirical. The obvious and direct method of finding out an empirical approximation to the simultaneous variations in the errors of estimation of each of two or more methods would be to run several hundred determinations by each method at the same time on each of a set of samples of milk containing, at least roughly, graduated numbers of bacteria. If determinations by two different methods that are assumed really to give estimates of the number of bacteria in milk are made at the same time on the same sample of milk, the estimates should be compared directly and not some function of them, as the logarithms. This is true because the effect of the increase of bacteria with time is eliminated by making both determinations at the same time.

The question is: How does the number of bacteria estimated by one method compare with the number of bacteria estimated by another method? The location (or mean measured from the true number of bacteria in the milk) of the distributions of the estimates of the number of bacteria can not be determined by this method. The mean numbers of bacteria in each lot of milk as obtained by two methods can be compared and if they differ markedly, then it can be concluded that one or both methods are definitely biased. It must be left to other considerations to show which is essentially the more accurate.

Since the plate method gives higher and then lower counts than the direct microscopic method, it is to be expected that for a certain range the mean counts will be in substantial agreement. Outside of this range the plate method shows a pronounced and progressive bias as compared with the direct microscopic method. The effects of variations in technic and in the types of bacteria present in the milk and of changes in the technician could also be approximated by repeated trials on the same lots of milk.

The foregoing discussion assumes that it is of interest to compare the estimates of the number of bacteria in milk as made by different methods. It may be that the limitations of the various methods and the unique knowledge obtained by each makes it not worth while to attempt a comparison of this kind (3). If, however, such a comparison is attempted and it is assumed that the methods employed actually give estimates of the number of bacteria present in milk, then the statistical methodology would be that outlined above.

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THE INFLUENCE OF ENVIRONMENTAL TEMPERATURE ON THE PERCENTAGE OF BUTTER FAT IN COW'S MILK*

H. J. BROOKS

Kansas Agricultural Experiment Station, Manhattan

It is generally accepted that there is an inverse correlation between the environmental temperature and the percentage of butter fat in cow's milk. It was with the aim of verifying this under Kansas conditions and specifically stating this relationship that the present study was made.

RÉSUMÉ OF PREVIOUS STUDIES

Eckles (1) states that regardless of when the lactation begins, the percentage of fat plotted followed a curve for the year, lowest in June and July and gradually rising to the highest point in December and January, and then declining again until midsummer. A total of 240 cows was tabulated.

White and Judkins (2) concluded that milk tests lower in fat content in the summer months than it does in the winter months, and that this variation is due to seasonal changes. This conclusion was drawn from data taken on 49 cows over a period of seven and one-half years.

Hills (3) says that from results obtained in a study of the local creamery butterfat tests of the milk of 30 herds in Vermont during the months of May, June and July, 1891, and July, August and September, 1892, "it points strongly to the probability that when cows are put on pasture the percentage of fat rises as the temperature falls, and falls as the temperature rises.

* Contribution No. 75 Department of Dairy Husbandry. Acknowledgment is made of the assistance rendered by Professor Salmon of the Department of Agronomy, Mr. Hodgson of the Department of Dairy Husbandry, and Professor Andrews of the Department of Education in the preparation and statistical interpretation of this study. Received for publication March 30, 1931.

In other words, the percentage of fat in milk varies inversely with the temperature changes."

Brooks (4) found that when warming a stable for cows during the months of December, January, February and March, 1895, there was a definitely lower percentage test in the wing that was warmed to 55°F. and maintained at this temperature.

Hays (5) concluded from a study of the University of Missouri dairy herd over a period of 258 days starting in January, in which the environmental temperatures were recorded, that, generally, the lower the temperature the higher the fat test. This variation amounted to 0.079 per cent for each 10° lowering of the temperature. In a second phase of this experiment, Hays kept two Jersey cows in a controlled temperature chamber in which the temperature ranged from 92.7° to 27°F—a spread of 65.7°. This variation was accompanied by a spread of 0.624 per cent test which gives an average of 0.095 per cent for each 10° lowering of the temperature.

Weaver (6) found from a study of the Iowa State College dairy herd over a period of one year that the fat test was highest during the first half of the winter, or during January, gradually declining to the second half of the summer, during August and early September, when the lowest test occurred, and then increasing rather rapidly in the fall. Ayrshire and Holstein tests were approximately 0.6 per cent lower in the second half of summer than in the first half of winter. Guernsey and Jersey tests were approximately 1.1 per cent lower. The butter fat tests were found to be lower with higher outside and inside temperatures.

Clothier (7) and Hooper (8) alone attribute the variation in percentage of fat to factors other than temperature or season of the year. The former finds it "impossible to believe that the season variations in butter fat content of the milk, observed in Arizona, are not due directly to changes in feed," and the latter concluded from a study of 88 Jersey cows, one-fourth of which freshened in each of four seasons, that the fat test runs lower while the cow is fresh, regardless of the time of the year she freshens, and there is no indication that the percentage of fat runs lower in July.

Ragsdale and Turner (9) found in a study of some 4100 Guern-

sey, Jersey and Holstein-Friesian Advanced Registry records that, irrespective of time of freshening, "the percentage of fat in milk when plotted follows a general curve, being lowest during the summer months, then gradually rising reaching a peak during the winter months and then again declining during the spring and summer." The peak was reached in December at 4.75 per cent and the lowest point in August at 4.32 per cent.

Ragsdale and Brody (10) concluded from a controlled experiment on ten animals over the period from March 1 to May 1 that "There is a relation between temperature and percentage of fat showing roughly an increase of about 0.2 per cent in the fat for a decrease of 10°F. in the temperature between the observed temperature limits." The animals were kept indoors during stormy days and cool nights and the barns were well ventilated though not artificially heated.

PLAN OF PROCEDURE

This study is concerned with the question of the influence of environmental temperature on the percentage of butter fat in cow's milk. Such factors as the stages of lactation and gestation, condition of animal, feeding and breed difference have been eliminated. To accomplish this only records of 365 days duration were used, and these were selected so as to have, as nearly as possible, the same number of animals freshening each month, and the same number of animals from each of the four major dairy breeds. This distribution is shown in table 1.

The data were coded by calendar months so that the animal's monthly production fell in the respective calendar month irrespective of the time of freshening. The totals thus gave the production of the group by the month irrespective of the time of freshening. A total of 409 lactations were taken from the records of the cows in the Kansas Agricultural Experiment Station dairy herd over the period from 1912 to 1927. The mean temperature for each month for this period was taken from the Kansas Weather Bureau Reports for the Manhattan district. In securing the average percentage of butter fat, true averages were determined in each case by dividing the total butter fat production by the

total milk production. Milk and butter fat production are expressed in pounds produced each day by the group for the respective months.

TABLE 1

Distribution by breeds of the number of animals freshing each month

BREED	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	TOTAL LACTATIONS
Holstein	9	9	11	9	6	12	9	9	8	11	8	10	111
Ayrshire	9	9	7	10	9	6	10	9	10	7	9	10	105
Jersey	9	9	5	7	8	6	11	9	11	6	9	6	96
Guernsey	9	7	12	6	11	4	3	9	6	11	9	10	97
Total	36	34	35	32	34	28	33	36	35	35	35	36	409

TABLE 2

Variations in the percentage of butter fat with the fluctuation in environmental temperature irrespective of time of freshening

MONTH	TEMPERATURE	AVERAGE TEST	AVERAGE DAILY MILK PRODUCTION	JERSEY	GUERNSEY	AYRSHIRE	HOLSTEIN
	°F.	per cent	pounds	per cent	per cent	per cent	per cent
January	29.0	4.23	23.5	5.39	4.80	3.96	3.49
February	31.2	4.16	24.5	5.38	4.82	3.87	3.47
March	43.9	4.01	25.3	5.28	4.71	3.81	3.42
April	54.4	4.07	26.3	5.27	4.74	3.76	3.37
May	64.5	4.01	26.9	5.18	4.66	3.72	3.41
June	74.3	3.95	25.7	5.01	4.55	3.67	3.36
July	78.5	3.92	23.7	4.75	4.38	3.66	3.39
August	77.9	3.83	24.9	4.78	4.43	3.63	3.26
September	70.4	4.01	24.7	5.12	4.72	3.75	3.38
October	57.7	4.04	24.2	5.24	4.83	3.75	3.38
November	44.1	4.11	23.8	5.45	4.94	3.87	3.43
December	31.3	4.25	23.0	5.64	4.93	3.94	3.54

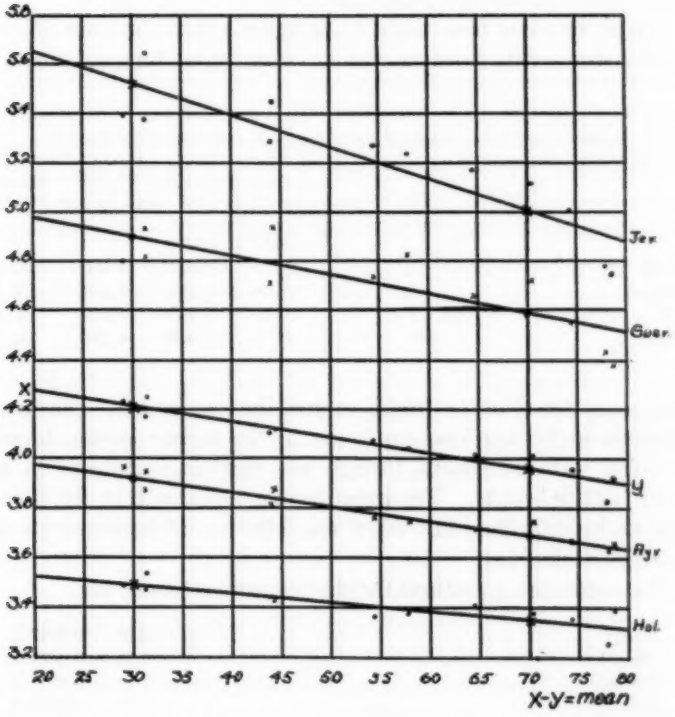
The seasons were designated as spring, summer, fall and winter consisting of March, April, May; June, July, August; September October, November; December, January, February, respectively.

The influence of environmental temperature on the percentage of butter fat is shown by the data in table 2.

These data show that there is a close inverse correlation between the percentage of butter fat in cow's milk and the environmental temperature. The coeficient of correlation for this relationship was found to be:

$$r = -0.872 \pm 0.046$$

Graph I
Trend in the Percentage of Butter Fat
with Variation in the Environmental Temperature



This relationship is further expressed in figure 1. In this graph the ordinate expresses the percentage of butter fat, and the abscissa the environmental temperature in degrees Fahrenheit. The mean data for all animals is expressed by the line $x-y$, while

that for the respective breeds is shown by the lines: Jer. (Jersey), Guer. (Guernsey), Ayr. (Ayrshire), and Hol. (Holstein).

Line x–y of figure 1 shows that with an increase in environmental temperature there is a uniform decrease in the percentage of butter fat. This relationship assumes a distinctly linear regression which may be expressed by the regression equation:

$$y = 4.41 - 0.0064\ X$$

in which y equals the percentage of butter fat and x equals the temperature in degrees Fahrenheit.

It may be noted from table 2 and figure 1 that the same general relationship exists between the environmental temperature and

TABLE 3

Summary of mean seasonal data irrespective of time of freshening

SEASON	MILK PER DAY	FAT PER DAY	PERCENTAGE OF BUTTER FAT	TEMPERATURE
	pounds	*pounds*		°*F.*
Spring	26.2	1.0637	4.060	54.2
Summer	24.7	0.9631	3.899	76.9
Fall	24.2	0.9806	4.052	57.4
Winter	23.7	0.9990	4.215	30.5

the percentage of butter fat for each of the four breeds. The more pronounced fluctuations are found in the higher testing breeds, however, with consistent though less marked variations in the lower testing breeds. The irregularities noted within the breeds tend to be smoothed out when the data for all breeds are combined as in line x–y.

The regression equations for the respective breeds are:

Jersey ..... $y = 5.90 - 0.0127\ X$
Guernsey ..... $y = 5.14 - 0.0078\ X$
Ayrshire ..... $y = 3.59 - 0.0033\ X$
Holstein ..... $y = 4.09 - 0.0056\ X$

The data for all animals were summarized by seasons and the means for the seasons were determined and are shown in table 3. This table brings out the similarity between the average tempera-

tures and the percentages of butter fat in the spring and fall seasons as contrasted with the extremes exhibited in the summer and winter periods. It is noted that the lowest mean temperature of 30.5°F. occuring in the winter season is accompanied by the highest average percentage of butter fat, while the highest mean temperature of 76.9°F. in the summer season is coincident with the lowest percentage of butter fat. The spring and fall seasons fall between these extremes in both mean temperature and average percentage of butter fat.

RELATION BETWEEN MILK PRODUCTION AND PERCENTAGE OF BUTTER FAT

It is frequently observed that there is an inverse relationship between the amount of milk produced and the percentage of butter fat in the milk. In order to determine the extent of this relationship in this study the average amount of milk produced daily each month was determined for all cows irrespective of time of freshening and correlated with the respective percentages of butter fat for these months. The coefficient of correlation for this relationship was found to be:

$$r = -0.1675 \pm 0.190$$

This would indicate that the amount of milk produced in the respective months was not a determining factor in the percentage of butter fat obtained for the group within that month when the factor of the stage of lactation was eliminated.

RELATIVE INFLUENCE OF THE ENVIRONMENTAL TEMPERATURE AND THE STAGE OF LACTATION ON THE PERCENTAGE OF BUTTER FAT

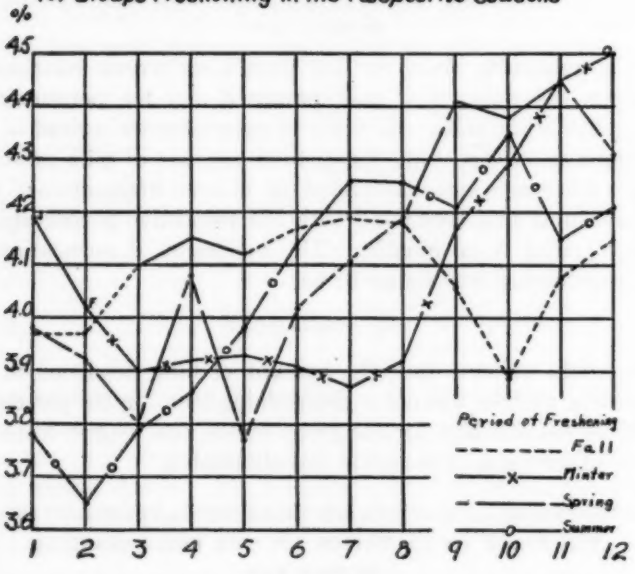
Ragsdale and Turner (11) and others have shown that as the normal lactation of a cow advances there is a noticeable decline in the percentage of butter fat from the first month to the second or third months of the lactation followed by a gradual increase in the percentage of butter fat which becomes more pronounced during the last months of lactation.

In view of the definite influence of the environmental tempera-

ture on the percentage of butter fat demonstrated in this and other studies, the question occurred as to the relative influence of the stage of lactation and the environmental temperature on the percentage of butter fat.

To study these relationships the data were segregated by seasons of freshening and were coded for each group to show the trend in the percentage of butter fat with the advance in the

Graph II
Trend in the Percentage of Butter Fat
for Groups Freshening in the Respective Seasons



lactation. These data are presented in figure 2. In this graph the ordinate expresses the percentage of butter fat and the abscissa the month of lactation. The center month of the season of freshening is taken as the first month on the graph in each case. In order to more clearly indicate the effect of temperature the winter season of December, January, February is shown in solid line in each case.

Group II shows that almost irrespective of the stage of lactation the high points in the percentage of butter fat occur in the winter period and the low points in the summer period. This is especially evident in the group freshening in the winter season. The percentage of fat drops rapidly the first months of the lactation, remains at a low level for the six months period from March to August inclusive, and then rises rapidly to the highest point in December as a result of the combined influence of decreasing temperature and the advanced stage of the lactation.

This graphic study indicates that the environmental temperature exerts a greater influence on the percentage of butter fat than does the stage of lactation. This observation is further

TABLE 4

Coefficients of correlation for the relationship between the environmental temperature and the percentage of butter fat in cow's milk, and between the stage of lactation and the percentage of butter fat in cow's milk

SEASON OF FRESHENING	ENVIRONMENTAL TEMPERATURE	STAGE OF LACTATION
Spring	-0.895 ± 0.039	$+0.397 \pm 0.171$
Summer	-0.579 ± 0.169	$+0.298 \pm 0.178$
Winter	-0.517 ± 0.143	$+0.429 \pm 0.159$
Fall	-0.328 ± 0.174	$+0.074 \pm 0.194$

emphasized by a comparison of the coefficients of correlation shown in table 4.

It is noted from table 4 that in every case the coefficients for the correlation between the environmental temperature and the percentage of butter fat for the groups freshening in the respective seasons are greater than those for the relationship between the stage of lactation and the percentage of butter fat for the groups freshening in the respective seasons.

The similarity between the coefficients for the winter freshening group is explained by the fact that the relative influences of the stage of lactation and the environmental temperature are essentially the same throughout with the exception of the fifth to eighth months of lactation in which case the percentage of butter fat is noticeably depressed contrary to the normal trend at

this stage of lactation due to the marked increase in environmental temperature in this period.

SUMMARY

1. This study confirms previous conclusions that there is a very close inverse correlation between the environmental temperature and the percentage of butter fat in cow's milk. This relationship may be expressed by the coefficient of correlation:

$$r = -0.872 \pm 0.046$$

2. This relationship assumes a distinctly linear regression and is characterized by the regression equation:

$$y = 4.41 - 0.0064\ X$$

3. The same relative relationship was found to maintain in each of the four dairy breeds studied, though marked by greater fluctuations in the higher testing breeds.

4. It was found that when the stage of lactation was eliminated the amount of milk produced by a group of cows in a given period did not appreciably affect the percentage of butter fat in that milk. The coefficient of correlation for this relationship between milk production and percentage of butter fat was:

$$r = -0.167 \pm 0.190$$

5. Environmental temperature exerts a greater influence on the percentage of butter fat of cow's milk than does the stage of lactation.

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A STUDY OF METHODS FOR DETERMINING NUMBERS OF MOULDS AND YEASTS IN BUTTER

2. THE INFLUENCE OF TEMPERATURE AND TIME OF INCUBATION*

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In routine quantitative microbiological tests of a control nature, temperature and time of incubation are important factors in the procedure of methods, especially if results from different laboratories are to be comparable. Temperature affects not only the ability of microörganisms to grow but also the rate of growth and should be such as to provide optimum conditions of growth for the types of organisms to be determined. The time factor in routine work is also important from the standpoint of availability of results and economy in laboratory equipment, especially in commercial laboratories.

A review of the literature reveals that there is considerable variation in the temperatures and incubation periods employed by various workers in determining the number of moulds and yeasts in butter. Hood and White (1) recommended a temperature of 25°C. for 5 days and this procedure is being used with satisfactory results in Canadian laboratories. Lund (2) employed a temperature of 25°C. counting Oidia at three days and yeasts and Penicillium at 5 days. Hunziker (3) recommended room temperature for 5 days, and Macy (4) used room temperature (20° to 25°C.) making the counts at 3 days. Bouska and Brown (5) found that yeasts and Oidia were of sufficient size to count at two or three days at room temperature.

Abbott (6) and Stiritz (7) employed a temperature of 30°C. for 5 days with the former counting moulds at 48 hours. McKay (8) stated that in the laboratory of the American Association of Creamery Butter Manufacturers plates for mould and yeast

* Received for publication April 17, 1931.

counts were incubated at 36°C. for 48 hours and a magnifying glass used in counting. Brown (9), some time later, stated that the procedure used was to incubate plates for 72 hours at 75°F. (24°C.). Parfitt (10) reported that he found many of the commercial laboratories using 37°C. for 48 hours, and Clerkin (11) used a temperature of 20°C. for 5 days.

The work of several investigators also shows a wide variation in temperature requirements for different species of moulds and yeasts. Harrison (12), in a study of 70 yeast cultures isolated from Canadian cheese, found that only 20 grew as well or better at 37°C. than at 25°C., while 30 gave very scant or no growth at 37°C. Hammer and Cordes (13) found the optimum temperatures for lactose fermenting yeasts from dairy products to be 37°C. for one species and 30°C. for another. Nelson (14) reported that some of the "common white" yeasts grew well at both room temperature and 37°C., while others grew well at room temperature but poorly or not at all at 37°C. Guilliermond (15) stated that for several of the species of pink or red yeasts the optimum temperature for budding was 22° to 25°C., while at temperatures of 30°C. some became weakened and at 37° to 38°C. many of the yeasts stopped vegetating.

Thom (16) found that 56 species of Penicillium grew normally at 15° to 25°C., the temperature affecting the rate of growth only, but that the green forms were prevented from growing at 37°C. Thom and Church (17) in a study of Aspergilli found that their laboratory cultures grew freely between 20°C. and 33°C.

The wide divergence in the temperature and time of incubation employed in making mould and yeast counts of butter made it seem advisable to study the influence of these factors on mould and yeast counts of butter with a view to the adoption of a uniform temperature and incubation period in order that results from different laboratories would be comparable.

METHODS

This study was carried out in two parts, in the first part comparative mould and yeast counts were made on 39 samples of butter and in the second part 40 cultures of representative yeasts isolated from the butter plates were used.

The butter samples included all grades of pasteurized and unpasteurized Canadian butter, the first 24 being from commercial lots while samples 25 to 39 were from exhibition butter. A preliminary count was made on the first twelve samples and suitable dilutions were then plated. Samples 13 and 24 were plated in dilutions of 1 cc. and 0.01 cc., while the majority of the exhibition butters were plated in only one dilution after the count for mould and yeast score had been made. For 1:10 dilutions, 10 cc. of butter were used in a 90-cc. water blank and for 1:100 dilutions, 1 cc. of butter was used in 99 cc. of water.

The yeast cultures were first picked to malt agar slopes and after good visible growth were transferred to malt broth. The broth cultures were then plated in high dilutions on malt agar and a well isolated colony from each culture was then transferred to a malt agar slope on which the cultures were carried. Incubation temperature was 25°C. for all transfers.

Before using for comparative counts, the yeast cultures were inoculated into malt broth and after 18 to 24 hours incubation at 25°C. a loopful of the broth culture was transferred to a 99 cc. water blank and 1 cc. of this dilution was used for plating.

Duplicate plates of each dilution were prepared for incubation temperatures of 25°, 30° and 37°C. The plates were counted after 48 hours and again after 5 days.

The medium used was Bacto malt agar, dehydrated, and acidified to pH 3.5 ± with a 5 per cent lactic acid solution just before using.

Counting was done with the aid of a hand lens as recommended in Standard Methods of Milk Analysis (18) and the results expressed as the average of the duplicate plates.

RESULTS FROM PLATING BUTTER SAMPLES

In table 1 are given the yeast counts of the butter samples for the different temperatures and incubation periods studied.

The data presented show that for the majority of samples there was not a significant difference in the counts at 25° and 30°C. for incubation periods of 48 hours and 5 days, but that there was a decided decrease in the counts at 37°C. after both periods of in-

TABLE 1

Comparison of yeast counts from butter at different temperatures and incubation periods

SAMPLE NUMBER	YEASTS PER CUBIC CENTIMETER					
	25°C.		30°C.		37°C.	
	48 hours	5 days	48 hours	5 days	48 hours	5 days
1		2,200	1,650	2,200	14	43
2		2,555	2,565	2,550	40	200
3		526,000	583,000	561,000	12,000	11,500
4		355	260	300	3	4
5		2,600	1,050	1,400	29	31
6		9,850	8,700	9,600	14	68
7	435	455	460	440	250	285
8	6,450	6,450	4,150	4,350	2,050	2,300
9	5,915	5,880	2,725	3,455	505	780
10	1,065	1,110	835	970	415	410
11	1,375	1,530	770	810	35	380
12	34,600	34,700	32,900	32,650	20,800	20,350
13	21,700	25,300	19,900	21,550	2,150	2,400
14	1,250	1,400	1,200	1,450	265	266
15	73	132	71	124	37	95
16	5,750	7,750	4,850	6,000	85	250
17	9,800	12,800	6,200	8,800	50	179
18	3,400	4,600	2,450	3,300	700	800
19	13,400	15,050	8,000	13,800	65	110
20	132	187	139	197	13	22
21	87,900	95,300	69,350	85,200	2,300	2,350
22	43,150	50,550	6,100	34,300	544	784
23	5,000	8,200	4,600	5,650	133	133
24	13,050	13,600	12,250	12,500	1,100	1,300
25	32	55	29	75	9	25
26	1	3	1	2	1	3
27	15	24	13	26	12	23
28	45	65	117	117	139	117
29	94	126	91	124	13	18
30	54	61	59	78	6	17
31	102	119	60	90	18	36
32	600	930	380	640	0	0
33	200	230	250	260	100	120
34	300	340	310	350	0	0
35	10	40	20	20	30	30
36	20,100	21,500	19,200	20,300	1,300	1,300
37	5,350	6,030	1,970	5,260	130	130
38	250	420	360	480	70	100
39	950	1,400	1,040	1,240	0	5
Averages....	*8,562	22,048	20,464	21,581	1,167	1,201

* For 33 samples only.

cubation. The results, however, show that at 5 days 28 samples had higher counts at 25° than at 30°C. although generally the increase was small. Even at 48 hours, 23 samples had higher counts at 25° than at 30°C. and in some cases the difference was quite noticeable, especially for sample 22. With the exception of sample 28, which was comparatively low count butter, all samples had lower counts at 37° than at 25° and 30°C., and in the majority of cases the differences were very marked, 3 samples failing to show any yeast colonies at the high temperature.

The average count of all cultures and counts of the majority of individual samples show a slight increase at all temperatures at 5 days as compared to 48 hours incubation. Generally the differences were of no practical significance but in a few cases at 30° and 37°C. the counts at 5 days were noticeably higher than at 48 hours. For 25°C. 31 samples had higher counts at 5 days than at 48 hours, for 30°C. 33 samples showed higher counts at 5 days, and for 37°C. the counts at 5 days were higher than at 48 hours for 29 samples.

In a few cases at each temperature the counts at 48 hours were higher than those recorded at 5 days which was probably due to two or more contiguous colonies growing together and counted as one at 5 days, while at 48 hours they may have shown as separate colonies under a hand lens.

The methods employed by various workers indicated that with the higher temperatures a shorter incubation period was used. When the yeast counts at 25°C. for 5 days are compared to the counts at 30° and 37°C. for 48 hours, it will be noted that the average counts at 25° and 30°C. for the respective incubation periods do not show a significant difference. This is largely due to the numerical difference in the count of sample 3 in favour of a temperature of 30°C. which is relatively much higher than the counts of the other samples. The average counts at 25°C. for 5 days and 30°C. for 48 hours, however, do not indicate the considerable differences in the counts for individual samples. The results show that 34 samples had higher counts at 25° than at 30°C., and in many cases the differences were quite marked. On a percentage basis the counts varied from 0.4 to 88 per cent

and for 16 samples the counts at 30°C. for 48 hours were over 40 per cent lower than at 25°C. for 5 days. The counts at 37°C. for 48 hours are very much lower for most samples than at 25°C. for 5 days or at 30°C. for 48 hours.

TABLE 2

Comparison of mould counts at different temperatures and times of incubation

SAMPLE NUMBER	MOULDS PER CUBIC CENTIMETER					
	25°C.		30°C.		37°C.	
	48 hours	5 days	48 hours	5 days	48 hours	5 days
1	0.0	4.5	7.5	8.5	0.0	0.0
2	0.0	5.5	3.5	5.5	0.0	0.0
3	87,500.0	87,500.0	86,000.0	75,000.0	70.0	70.0
4	0.5	60.5	5.0	31.0	0.0	0.0
5	1.5	8.5	1.5	9.5	0.0	0.0
6	20.0	27.5	38.0	30.0	1.0	3.0
7	5.0	5.5	8.5	8.5	0.5	3.5
8	15.0	16.5	12.5	14.5	0.0	1.0
9	2.0	2.0	0.5	1.0	0.0	0.0
10	8.0	8.5	6.5	6.0	0.0	0.0
11	2.0	4.0	1.0	1.5	0.0	0.0
12	1,350.0	1,400.0	1,450.0	1,450.0	70.0	90.0
13	78.0	100.5	64.0	73.0	0.5	0.5
14	38.0	51.0	38.0	43.5	1.0	1.5
15	1.0	8.0	0.5	3.5	0.0	2.0
16	11.5	12.0	11.0	11.0	8.0	8.0
17	1.0	1.0	0.5	1.0	0.0	0.0
18	3.0	7.0	3.0	6.0	0.0	1.0
19	58.5	61.0	56.5	62.0	0.0	0.5
20	9.0	12.0	7.0	11.0	0.0	0.0
21	7.0	10.0	0.0	4.5	0.0	1.0
22	56.0	71.0	52.0	53.5	0.5	1.0
23	28.5	58.0	14.5	14.5	1.0	1.0
24	22.5	60.0	14.5	15.0	22.0	22.0
Averages....	3,717.0	3,729.0	3,658.0	3,202.0	7.3	8.6

In table 2 are shown the mould counts of 24 samples of commercial butter at different temperatures and incubation periods. The mould counts for the exhibition butters are not given as in most cases there were none or only a few colonies growing on the plates.

The data show that there was no marked variation in the mould counts for temperatures of 25° and 30°C. at 48 hours and 5 days incubation, but that the counts at 37°C. were very much lower in most cases than at 25° and 30°C., and for 9 samples moulds failed to grow at 37°C. when colonies were present on the plates incubated at the lower temperatures. The results of individual samples, however, show that 16 samples had higher counts at 25° than at 30°C., 2 samples had the same count and 6 samples had higher counts at 30° than at 25°C. for 5 days. The same general trend is found in the counts at 48 hours.

When the counts at 25°C. for 5 days are compared to those at 30° and 37°C. for 48 hours, it will be noted that both average and individual counts vary only slightly at temperatures of 25° and 30°C., while the counts at 37°C. are much lower.

The counts after the two different incubation periods show only slight variations for all three temperatures. At 25° and 37°C. the average counts are slightly higher at the 5 days incubation period, while the average count at 30°C. is higher at 48 hours due to the numerical difference in the mould counts of sample 3, which is very much higher than the counts for other samples. Excluding sample 3, the counts at 5 days are higher than for 48 hours at 30°C.

While the differences in the mould counts of individual samples at the different incubation periods for each temperature were of no practical significance, the results showed that for 25°C. 21 samples had higher counts at 5 days than at 48 hours, and for 30°C. 17 samples had higher counts after the longer incubation period. For a temperature of 37°C. there was practically no variation in the counts due to the small number of mould colonies appearing on the plates.

RESULTS FROM PLATING PURE YEAST CULTURES

In table 3 the colony counts for the yeast cultures at different temperatures and times of incubation are tabulated. No attempt was made to identify the yeasts other than to note the colony growth and colour on malt agar. For convenience, the cultures were grouped together in the table. The first 29 cul-

TABLE 3

Colony counts of yeast cultures at different temperatures and times of incubation

CULTURE NUMBER	25°C.		30°C.		37°C.	
	48 hours	5 days	48 hours	5 days	48 hours	5 days
1	466	483	479	487	455	463
2	491	513	448	454	0	0
3	525	535	573	570	498	507
4	480	486	464	470	469	469
5	322	339	329	338	106	123
7	358	374	378	389	389	396
8	537	551	528	528	484	489
9	169	171	145	171	0	0
10	89	92	65	68	9	10
13	823	836	796	814	40	123
14	365	368	294	363	0	0
15	155	168	124	155	0	0
16	474	497	461	496	0	0
17	321	341	316	333	0	0
19	120	121	135	135	139	145
20	179	181	186	189	160	163
24	235	247	216	250	0	0
25	279	285	287	291	0	0
26	163	200	35	132	0	0
27	354	369	322	339	0	0
28	259	260	242	248	0	0
30	619	638	629	650	593	602
31	177	193	190	203	154	178
34	79	81	90	93	83	87
35	209	215	202	213	0	0
37	181	184	173	184	117	165
38	107	109	100	100	91	95
39	524	537	482	490	0	0
40	307	345	325	341	132	238
6	253	260	246	251	0	0
12	295	296	269	279	0	0
18	86	86	91	91	0	0
21	260	267	273	285	0	0
29	280	309	309	325	0	0
32	220	245	204	210	0	0
33	127	135	123	129	0	0
36	219	239	234	252	0	0
22	59	63	0	5	0	0
23	132	194	35	99	0	0
41	37	41	0	10	0	0
Averages....	283	296	270	286	98	106

tures, from 1 to 40, were different types of white yeasts; cultures 6 to 36, 8 in all, belonged to the pink yeasts; and the last three, cultures 22, 23 and 41, appeared to be identical to the species Chromotorula ochracea described by Harrison (12).

A comparison of the counts at different temperatures shows that at 37°C. 24 cultures, or 60 per cent, failed to make any growth even at a 5 day incubation period, 4 cultures made some growth at 37°C., but the number of colonies was appreciably less than at 25° or 30°C., while the counts for 12 cultures were comparable to the results obtained at the lower temperatures. Of the 24 cultures that failed to make any growth at 37°C., 13 were white yeasts while all the cultures of pink yeasts and the other chromogenic type failed to grow. The four cultures that had counts considerably lower at 37° than at 25° and 30°C. belonged to the group of white yeasts. At 30°C. all but 5 of the cultures made as good growth as at 25°C. The three cultures of the Chromotorula ochracea type did not grow well at 30°C., and cultures 10 and 26 did not make as good growth at 30° as at 25°C. All cultures made good growth at 25°C.

The data in table 3 also show that with few exceptions there was no significant variation in the counts at 48 hours and at 5 days for all three temperatures. At 25°C. there was practically no difference in the counts at 48 hours and at 5 days. At 30°C. the counts for cultures 23 and 26 were appreciably higher at 5 days than at 48 hours, and for cultures 22 and 41 there were a few colonies visible at 5 days that did not show at 48 hours even with the aid of a hand lens. At 37°C. 13 cultures showed very slight differences in the counts at 48 hours and at 5 days, 3 cultures had noticeably higher counts at 5 days, while 24 cultures failed to make any growth even at 5 days.

At all temperatures, however, the average counts were slightly higher at 5 days than at 48 hours.

DISCUSSION OF RESULTS

The most noticeable effect of temperature on the mould and yeast counts of butter and on the growth of yeasts in pure culture was found at 37°C. At this temperature the counts of both

moulds and yeasts were much lower than at 25° and 30°C. and in many cases the types of moulds and yeasts present in the butter failed to make any growth. At 30°C. for most of the samples the counts were comparable to those obtained at 25°C., but in a few cases there was a noticeable decrease in the counts of yeasts. At 25°C. all moulds and yeasts made good growth and the counts were generally higher at this temperature.

The marked decrease in the counts of the butter samples at 37°C. was undoubtedly due to the inhibiting effect of this temperature on the growth of some of the types of moulds and yeasts present in the butter. Although no detailed study was made to identify the types of moulds and yeasts appearing on the plates, a few observations were made regarding the occurrence of some of the more easily recognized types at the different temperatures of incubation. It was noted, for example, that there were numerous colonies of pink yeasts on the plates from sample 29 at 25° and 30°C. but none were present on the plates incubated at 37°C. The inhibiting effect of a temperature of 37°C. on pink yeasts was further substantiated in the results obtained when pure cultures of this type of yeasts were plated. In butter samples 4 and 6, greenish coloured moulds, probably of the Penicillium type, were present on the plates at 25° and 30°C. but were not found at 37°C., and for samples 3, 7, 10, 12, 13, 14, 19, 22, 23 and 24, the plates showed numerous mould colonies of the Oidium lactis type at 25° and 30°C. but at 37°C. there was a decided decrease in the number of colonies. These results are quite in accord with the results of other workers who observed that many of the moulds and yeasts were not able to grow at 37°C. or at best gave only a scant growth.

The data indicated clearly that a temperature of 37°C. was unsuitable for the incubation of plates in the routine analysis of butter for moulds and yeasts as the counts obtained at this temperature gave a wrong picture of the mould and yeast content of the majority of the butters analyzed. Reports of mould and yeast counts at 37°C. would be misleading to the buttermakers and creamery managers in interpreting the results in terms of the sanitary conditions surrounding the manufacture of the butter.

Even at 30°C. the yeast counts of some of the butters were so much lower than those obtained at 25°C. that they gave a better rating to the butter in this regard than was warranted.

Observations on the plates incubated at 37°C. also showed that many of the yeast colonies took on a brownish "burnt" tinge. In almost every case the medium was so dried out that it was cracked around the edges and through the center, which may have been an inhibiting factor to the growth of some of the moulds and yeasts.

Although the data presented indicate that the length of the incubation period made no significant difference to the mould and yeast counts of the butter samples and the colony counts of the yeast cultures, it should be remembered that a good hand lens was used in counting at 48 hours. For the majority of the butter samples and cultures of yeasts the counts would have been appreciably lower at 48 hours if the counting had been done with the naked eye. Many of the colonies of yeasts were so small that they were only observed after a very careful examination of the plates with the hand lens, and would have been entirely overlooked otherwise.

With the pure cultures of yeasts it was observed that a few of the white yeasts and all of the pink yeasts developed to sufficient size so as to be counted easily with the naked eye at 48 hours, but with many of the cultures, the colonies were too small to be visible without the aid of a hand lens. At 5 days incubation,however, all yeast colonies, both from butter samples and from the pure cultures, were easily seen.

The counts of the moulds for incubation periods of 48 hours and 5 days showed very little difference and all the moulds were fairly easily observed at 48 hours with the naked eye. When mould colonies are numerous on the plate it would be better to count at 48 or 72 hours, as at 5 days some of the more closely situated colonies may have grown together and would be difficult to distinguish as individual colonies.

It was also noted that the size of the mould and yeast colonies that grew at the three temperatures employed did not depend so much on the temperature as on the length of the incubation pe-

riod. The higher temperatures of 30° and 37°C. did not induce quicker development of the colonies so that they were more easily observed after a shorter incubation period. There was no noticeable difference in the size of the colonies able to grow at the temperatures used, and the counts of the plates incubated at 25°C. for 48 hours were made as easily and quickly as were the counts of plates incubated at 30° and 37°C.

If control laboratories making numerous analyses of butter for moulds and yeasts desire to use a shorter incubation period in order to make results more quickly available and to economize in equipment, the data obtained in this study indicate that there is no advantage in using a higher temperature than 25°C. At 25°C. the counts generally are higher than at 30° or 37°C. and from the standpoint of size of colonies and ease of counting, the plates incubated at 25°C. gave just as satisfactory results.

If an incubation period of less than 5 days and especially of only 48 or 72 hours is used it is necessary to use a good hand lens in counting or the yeast counts will be much too low.

SUMMARY AND CONCLUSIONS

The data obtained in this study show that the average mould and yeast counts of all samples and the counts for the majority of individual samples were slightly higher at 25° than at 30°C. for both incubation periods of 48 hours and 5 days, although the differences could not be considered of practical significance. A few of the yeast cultures, however, did not grow as well at 30° as at 25°C. as indicated by the number of colonies. At 37°C. the mould and yeast counts in almost all cases were appreciably lower than at 25° and at 30°C., due to the fact that some of the types of moulds and yeasts did not grow at all or made only scant growth at this high temperature.

When a temperature of 25°C. for 5 days was compared to 30°C. for 48 hours, there was a considerable variation in the yeast counts of individual samples in favour of the lower temperature for the longer incubation period. Many of the counts at 30°C. for 48 hours were over 40 per cent lower than at 25°C. for 5 days. The counts at 37°C. for forty-eight hours were very much lower

than at the other two combinations of temperature and incubation period.

The length of the incubation period did not affect the mould and yeast counts to any marked degree at any of the temperatures when a good hand lens was used in counting after 48 hours. The results show, however, that in general the counts were higher at an incubation period of 5 days than at 48 hours. If counting at the shorter incubation period had been done with the naked eye the counts would have been appreciably lower than recorded, as many of the yeast colonies were not apparent without the aid of a lens. At 5 days moulds and yeasts were easily counted with the naked eye at all temperatures used.

The size of the colonies and rate of growth of the moulds and yeasts growing at all temperatures was not influenced to any noticeable extent by temperatures of 30° and 37°C. as compared to 25°C. but was due rather to the length of the incubation period. It was evident that even for the short incubation period of 48 hours there was no advantage in using a higher temperature than 25°C. from the standpoint of size of colonies and rapidity of growth.

The data presented indicate that if mould and yeast counts of butter analyzed at different laboratories are to be comparable a uniform temperature and incubation period should be adopted, and 25°C. for 5 days gave the most satisfactory results in this study. If laboratory conditions necessitate a shorter incubation period than 5 days, counting should always be done with the aid of a good hand lens.

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EFFECT OF SINGLE AND DOUBLE HOMOGENIZATION OF CREAM UPON COAGULATION BY HEAT AND RENNET AND UPON SEPARATION OF THE FAT*

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The widespread use of the homogenizer in the processing of dairy products has made desirable a better knowledge of the physical changes which occur during homogenization. Alterations in the physical equilibria of the milk fat appear to be capable, under certain conditions, of changing the heat stability of the product fully as much as small shifts in pH or in salt balance. Consequently, a change in heat coagulation caused by a change in the distribution of the fat phase can be considered as a part of the general heat stability problem (17).

The effect of homogenization upon rennet coagulation is of interest because the results obtained indicate that changes in the condition of the fat phase may be of importance in rennet action. Workers in the past have not considered the effect upon rennet coagulation of an altered fat equilibrium such as is produced by homogenization.

In the manufacture of sterile cream two factors are at present causing some difficulty, the instability of the cream toward heat and the fat separation which occurs while in storage. A quantitative study has been made of the increase in heat stability which may result from rehomogenization and also of the degree of fat separation in homogenized cream during long periods of storage.

Burgwald (2) found the susceptibility of cream to feathering in coffee was increased when the product was homogenized.

The effect of single stage homogenization upon the heat stability of creams of different fat percentages when temperature

* Received for publication April 16, 1931.

and pressure are varied has been investigated by Webb and Holm (17). Maximum stability was always attained when a preheating temperature of 80°C. (176°F.) was used. Increases in homogenization pressure and in the fat content of the homogenized cream decreased stability. Further application of these principles to the manufacture of sterile cream has been shown (16).

The decreased stability of cream resulting from homogenization appears to be associated in some way with clumping of the fat globules (17). It has been noted (13) (5) (1) that fat clumping becomes greater as the pressure of homogenization is increased. Doan (7) (8) has shown that increased fat clumping is accompanied by increases in viscosity and in the tendency of cream to feather in coffee and by decreased stability toward coagulation by alcohol. The protein stability relations and changes in viscosity measured by these various methods agree with the data of Webb and Holm (17) obtained by measurements of the time of heat coagulation of homogenized creams.

During the last few years the two-stage valve has found much favor where homogenization of dairy products is practiced. Double homogenization has been shown by Doan (8) to affect protein stability in the same manner as when a two-stage valve is used. Doan also found clumping was decreased and stability increased at pressures of 3000–1000 pounds in comparison to the values obtained by a single homogenization at 3000 pounds.

Tracy and Ruehe (14) observed that the feathering of homogenized cream in coffee could be decreased by use of a second stage valve, providing the pressure used on the second homogenization did not exceed that used on the first valve.

In a recent study on ice cream mixes, Hening (10) has clearly shown that a very considerable reduction in the size of the fat clumps can be brought about in a mix homogenized at 2000 pounds pressure by rehomogenizing four times at 200 pounds pressure.

Either rehomogenization or use of a two-stage valve has been shown to decrease the viscosity of cream or ice cream mixes (12) (13) (9) (8) (10) (1). As has been mentioned, various results

indicate that such a decrease in viscosity is associated with less clumping and greater heat stability.

Some evidence has been obtained showing that the concentration of calcium salts present in a homogenized product influences its heat stability. Tracy and Ruehe (14) showed that an excess of calcium present in homogenized cream may cause its feathering in coffee. Addition of calcium lactate to ice cream mixes before homogenization caused an increase in viscosity and size of fat clusters, according to the work of Hening and Dahlberg (11). Addition of these salts after homogenization did not produce this marked effect. Dahlberg and Marquardt (3) consider the cause of the formation of fat clusters in milk to be due to the presence of a maximum quantity of calcium ions, which, by imparting some positive charges to the weak, negatively charged fat globules, create an electrical affinity between the globules. The loss of creaming ability in heated milk was considered as being due to a precipitation of the calcium salts. This view has also been recently favored by Doan (6).

EXPERIMENTAL

Effect of homogenization upon coagulation by heat and by rennet

The homogenizer used was a single stage Progress machine of 60 gallons capacity per hour. In cases where double homogenization was used, the second pressure is written after the first but separated from it by a hyphen.

Since the homogenization of a cream so greatly affects its heat stability, it appeared that some interesting results might be obtained by making comparisons between heat coagulation and coagulation by other means. Accordingly, coagulation by heat, by alcohol, and by rennet were compared.

It has been shown by Doan (8) that homogenization of a cream affects its stability toward alcohol in the same manner as it influences its heat stability. These results were confirmed in this work and it was found that curves drawn for coagulation by alcohol would parallel those established for heat stability.

The stability of homogenized cream toward rennet coagulation was investigated. One-half gram of powdered rennet (Eimer

and Amend, strength 1:30000) was dissolved in 200 cc. of distilled water. A solution was freshly made for each experiment.

The test was carried out as follows: 5 cc. of rennet solution was added to 230 cc. of cream at 37°C. (98.6°F.). After being mixed well in a 250-cc. bottle the cream was placed in a water bath at 37°C. (98.6°F.). It was slowly syphoned out of the bottle by means of a capillary tube and was allowed to run down the side of a clean glass beaker against a dark background so that the first trace of curd could be readily distinguished. The time of coagulation is given as the minutes which elapsed from the time the rennet was added until the first visible curd was produced. The limit of error of the method was found to be ± 0.1 minute.

The method of heat coagulation used was the usual one employed in this laboratory. The product was placed in baby-size tins and sterilized at 120°C. (248°F.) in a pilot sterilizer. The sterilizer is so equipped that cans may be withdrawn at intervals without interrupting the experiment. The time of coagulation was taken upon the appearance of the first visible curd, the limit of error being ± 1.0 minute.

Data obtained comparing coagulation by heat and by rennet are plotted in figure 1. Cream of 20 per cent fat was preheated to 60°C. (140°F.) and 80°C. (176°F.) but it was not held at the preheating temperature. It was homogenized immediately after heating and the coagulation time was then determined. This was repeated with cream containing 10 per cent fat. The unhomogenized check samples received the same heat treatment as the homogenized samples.

A study of figure 1 shows that homogenized cream coagulated by heat and by rennet gives the same type of curve. Increasing pressures of homogenization decrease stability. Low fat content and high preheating temperatures increase the stability of homogenized creams toward coagulation by heat and by rennet.

The effect of a variation in the milk-solids-not-fat content of creams containing 20 per cent fat upon their stability toward heat and rennet was investigated. The percentage of solids-not-fat was obtained by the addition either of water or of condensed skim milk as the case required. All samples were preheated to 80°C.

(176°F.) and half of each was then homogenized at 3000 pounds pressure. The time of coagulation by heat and by rennet was observed as described previously.

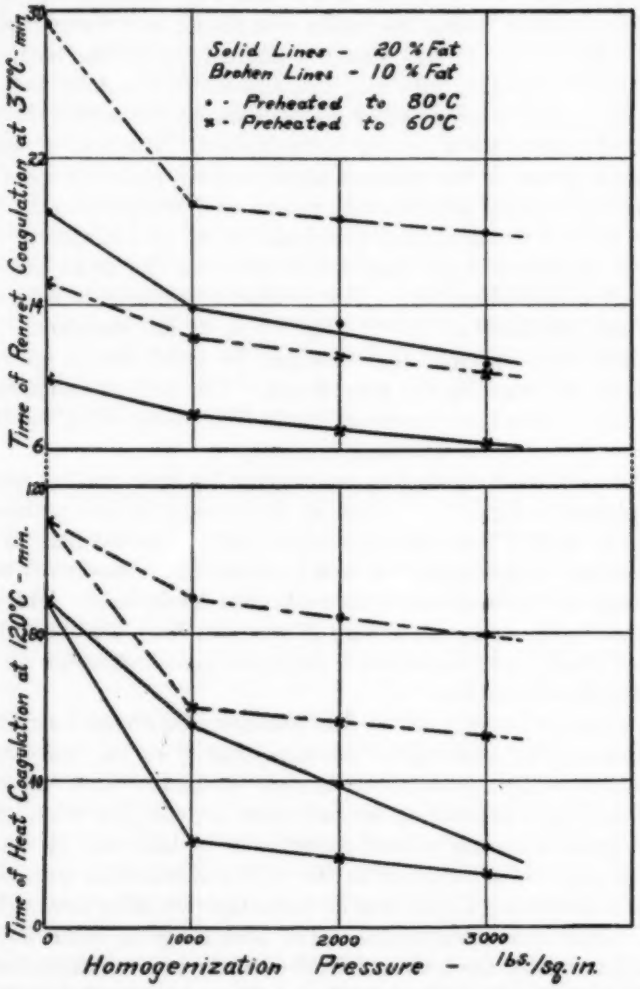

FIG. 1. SHOWING THE RELATIONSHIP OF HEAT COAGULATION AND RENNET COAGULATION TO THE PREHEATING TEMPERATURE AND HOMOGENIZATION PRESSURE OF CREAM OF 10 AND 20 PER CENT BUTTERFAT CONTENT

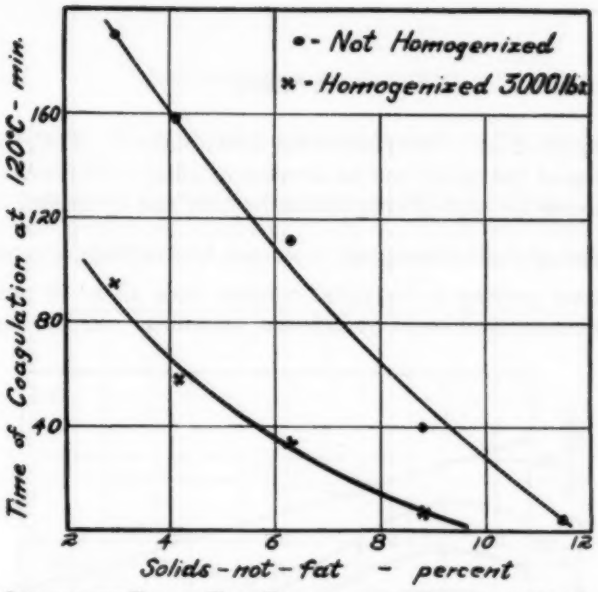

FIG. 2. SHOWING THE TIME OF HEAT COAGULATION OF CREAM OF 20 PER CENT FAT AS AFFECTED BY A VARIATION IN MILK-SOLIDS-NOT-FAT AND BY HOMOGENIZATION

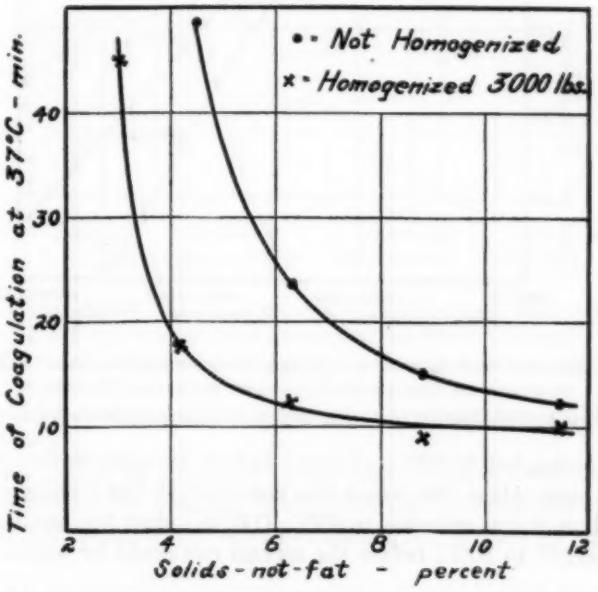

FIG. 3. SHOWING THE TIME OF RENNET COAGULATION OF CREAM OF 20 PER CENT FAT AS AFFECTED BY A VARIATION IN MILK-SOLIDS-NOT-FAT AND BY HOMOGENIZATION

In figures 2 and 3 are plotted the data obtained. Both homogenization of the cream and an increase in solids-not-fat are shown to decrease the time of coagulation by heat and by rennet.

Effect of double homogenization upon heat stability of cream

Creams varying in butterfat content from 15 to 30 per cent were homogenized twice at different pressures. All the samples

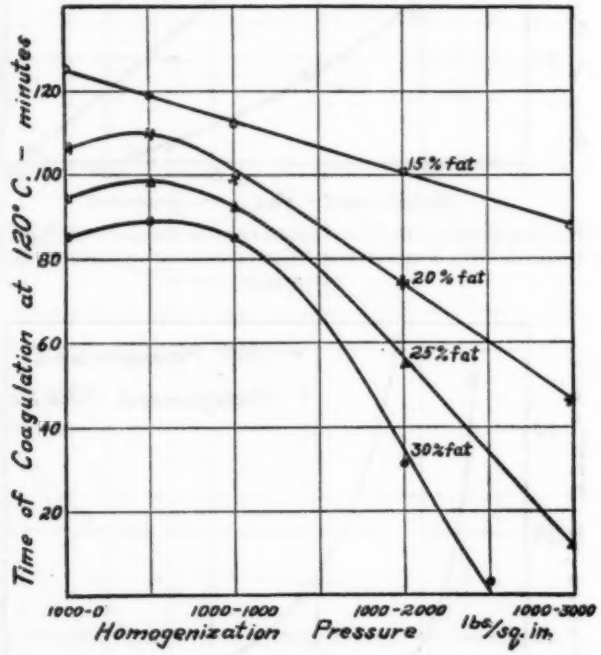

FIG. 4. SHOWING THE EFFECT OF DOUBLE HOMOGENIZATION UPON THE HEAT STABILITY OF CREAMS OF DIFFERENT BUTTERFAT CONTENTS

First homogenization pressures, 1000 pounds; second pressure varied

were preheated to 80°C. (176°F.) before homogenization and in those cases where the cream was run through the machine a second time, it was reheated to 80°C. (176°F.) since the temperature dropped 5° to 10°C. before the second run could be made. The

heat stability of the samples was determined in the sterilizer at 120°C. (248°F.).

Representative data from this work, which was repeated several times, are plotted in figures 4, 5 and 6. Three initial pressures were used, 1000, 2000, and 3000 pounds. After treatment at

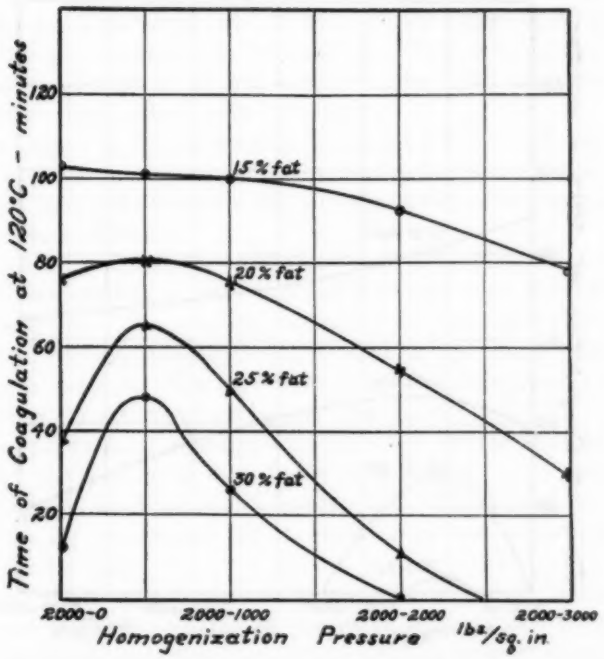

FIG. 5. SHOWING THE EFFECT OF DOUBLE HOMOGENIZATION UPON THE HEAT STABILITY OF CREAMS OF DIFFERENT BUTTERFAT CONTENTS
First homogenization pressure, 2000 pounds; second pressure varied

these basic values, the cream was rehomogenized at various pressures.

The stability of cream of 15 per cent butterfat was in every case decreased by a second homogenization at pressures of from 500 to 3000 pounds. Cream containing 20, 25, and 30 per cent

butterfat attained maximum stability when a second homogenization pressure of 500 pounds was used. With a fat content of 20 per cent, a second homogenization at 1000 pounds appeared of little or no advantage in increasing stability. In the case of creams containing 25 and 30 per cent butterfat, a marked im-

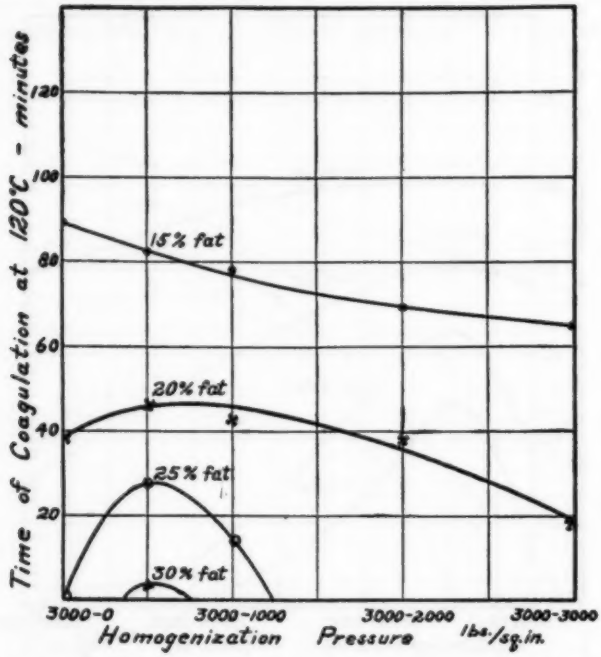

FIG. 6. SHOWING THE EFFECT OF DOUBLE HOMOGENIZATION UPON THE HEAT STABILITY OF CREAMS OF DIFFERENT BUTTERFAT CONTENTS
First homogenization pressure, 3000 pounds; second pressure varied

provement in stability results when a second homogenization of 500 to 1000 pounds is practiced. Double homogenization when the first stage was not over 3000 pounds and the second ranged from 2000 to 3000 pounds, always decreased stability over the single stage value.

Rate of rise of fat in homogenized cream

In the preparation of sterile cream for the retail market, difficulty may be experienced in preventing excessive separation of the fat after periods of undisturbed storage.

Von Sobbe (19) noted a slight rise of fat from homogenized milk allowed to stand in tall glass cylinders. The milk originally contained 3.3 per cent fat. It gave in the upper third of the cylinder, after seventy-two hours, a test of 3.85 per cent fat when homogenized, and 14.50 per cent fat when not homogenized. Longer storage periods were not used.

The degree of fat separation in creams of 20.5 and 16.5 per cent fat homogenized at various pressures has been investigated after undisturbed storage of the samples at room temperature for long periods of time.

In this work the cream was preheated to 80°C. (176°F.), homogenized immediately at the required pressure, and sterilized in baby-size tins. The cans had a capacity of 180 cc. and the inside height of the can was 60.0 mm., this being the actual height of the cream column. The cans were placed in undisturbed storage at room temperature, which averaged about 25°C. (77°F.). After various intervals of standing the tins were opened without disturbing the fat layer and the contents were very carefully skimmed off in three equal layers—top, middle, and bottom. Analysis for percentage fat in each layer was made by the Babcock fat test.

Representative data are given in tables 1 and 2. Both the 20.5 and 16.5 per cent fat creams were homogenized once and some were rehomogenized at 500 to 4000 pounds pressure. In the cases where samples were homogenized twice, the second pressure was the same as the first. The sum of the fat percentages for the three layers of each sample should equal three times the percentage fat in the original cream. The deviation from this figure, 61.5 for 20.5 per cent cream and 49.5 for 16.5 per cent cream, represents the probable error in the method. This error varies in most cases within 0.5 per cent fat on each analysis.

The effect of single and double homogenization of 20.5 per cent

TABLE 1

Effect of homogenization and rehomogenization at various pressures upon the change in butterfat distribution during storage

Butterfat content of cream 20.5 per cent

HOMOGENIZATION PRESSURE	CREAM LAYER ANALYZED	FAT DISTRIBUTION AT END OF STORAGE PERIOD					
		2 days	1 week	2 weeks	4 weeks	7 weeks	16 weeks
pounds per square inch		*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
0	Top layer	53.0	59.0	61.0	63.0		
	Middle layer	9.0	1.0	1.6	0.4		
	Bottom layer	1.5	0.5	0.1	0.1		
500	Top layer	26.0	36.0	47.5	52.0	57.0	
	Middle layer	20.5	16.5	13.0	8.0	4.5	
	Bottom layer	16.5	7.5	3.2	0.4	0.2	
500–500	Top layer	23.5	30.0	39.5	48.0	52.0	56.0
	Middle layer	20.5	19.0	15.5	11.5	5.0	5.5
	Bottom layer	18.5	12.5	7.5	2.5	1.5	
1000	Top layer	23.5	28.5	35.0	42.5	51.0	
	Middle layer	21.0	19.5	17.0	13.0	9.0	
	Bottom layer	18.5	13.5	7.2	3.0	1.0	
1000–1000	Top layer	21.5	26.0	31.5	36.5		53.0
	Middle layer	21.0	20.0	19.5	16.5		10.0
	Bottom layer	20.0	16.5	12.5	8.0		0.0
2000	Top layer	22.0	24.0	27.5	33.5	39.0	49.0
	Middle layer	21.5	20.5	20.0	18.5	17.0	11.5
	Bottom layer	19.5	17.5	15.0	11.0	4.5	0.5
2000–2000	Top layer	22.0	22.5	24.5	28.0	33.0	45.0
	Middle layer	20.5	21.0	20.5	20.0	19.0	13.5
	Bottom layer	20.5	19.5	17.0	14.0	10.0	2.5
3000	Top layer	21.5	23.0	25.0	28.0	33.0	43.0
	Middle layer	21.0	20.5	19.5	20.0	19.0	17.5
	Bottom layer	20.5	18.0	16.5	13.0	10.0	0.6
3000–3000	Top layer	21.0	21.5	23.0	25.0	28.5	37.0
	Middle layer	21.0	21.0	21.0	21.0	20.0	18.5
	Bottom layer	21.0	20.0	18.0	15.5	13.5	6.0
4000	Top layer	22.0	24.5	25.0	28.0	30.5	
	Middle layer	20.5	22.0	22.5	24.5	25.0	
	Bottom layer	20.5	16.0	14.5	11.5	9.5	
4000–4000	Top layer					26.0	
	Middle layer					21.0	
	Bottom layer					15.5	

TABLE 2

Effect of homogenization and rehomogenization at various pressures upon the rate of butterfat separation during storage

Butterfat content of cream 16.5 per cent

HOMOGENIZATION PRESSURE	CREAM LAYER ANALYZED	TIME OF STORAGE AT ROOM TEMPERATURE					
		2 days	1 week	2 weeks	4 weeks	7 weeks	2½ years
pounds per square inch		*per cent*	*per cent*	*per cent*	*per cent*	*per cent*	*per cent*
0	Top layer	47.5	48.5	48.5			
	Middle layer	0.7	0.5	0.3			
	Bottom layer	0.1	0.1	0.1			
500	Top layer	20.5	25.0	29.0	36.0	41.0	44.0
	Middle layer	16.0	14.5	12.5	9.0	9.0	1.7
	Bottom layer	13.0	10.0	7.0	2.5		
500–500	Top layer	19.5	23.5	28.0	34.0	38.0	47.5
	Middle layer	16.0	16.0	13.5	10.0	10.0	2.7
	Bottom layer	14.0	11.0	7.0	3.5		
1000	Top layer	21.5	26.5	30.0	40.0	42.0	48.0
	Middle layer	16.5	14.5	11.5	8.0	8.0	1.8
	Bottom layer	12.0	8.5	5.5	2.3		
1000–1000	Top layer	19.0	22.5	26.0	31.5	39.5	46.0
	Middle layer	16.5	16.0	14.0	11.0	11.0	1.1
	Bottom layer	13.5	10.5	8.5	5.0		0.1
2000	Top layer	18.5	21.5	25.0	31.0	35.0	44.0
	Middle layer	16.5	16.0	14.0	12.5	14.0	2.4
	Bottom layer	14.5	12.0	9.5	6.0		
2000–2000	Top layer	17.5	20.0	21.5	25.0	30.5	42.0
	Middle layer	16.5	16.5	16.0	15.0	18.0	3.2
	Bottom layer	15.5	13.5	12.0	9.5		0.1
3000	Top layer	18.0	20.0	22.0	26.0	31.0	41.0
	Middle layer	16.5	16.5	16.0	13.5	20.0	3.3
	Bottom layer	15.0	13.0	12.0	8.5		
3000–3000	Top layer	17.0	18.5	19.0	21.5	26.5	39.5
	Middle layer	16.5	17.0	16.5	15.5	23.0	3.6
	Bottom layer	16.0	15.0	13.0	11.0		0.1
4000	Top layer	17.5	19.0	20.0	24.0	28.0	39.0
	Middle layer	16.5	16.0	16.0	14.5	20.0	4.3
	Bottom layer	15.5	14.0	13.5	10.0		
4000–4000	Top layer	17.0	17.5	19.0	20.0	23.0	37.0
	Middle layer	16.5	16.5	16.5	16.0	27.0	4.5
	Bottom layer	16.0	15.5	14.0	12.0		0.1

cream upon the rate of rise of the fat during storage is shown in figure 7. The figure is plotted from the values found in table 1. On the ordinate is the total fat content of the top layer of cream at the various pressures of homogenization, while against this is plotted the time of storage in weeks.

The data show that in general increasing pressures of homogeni-

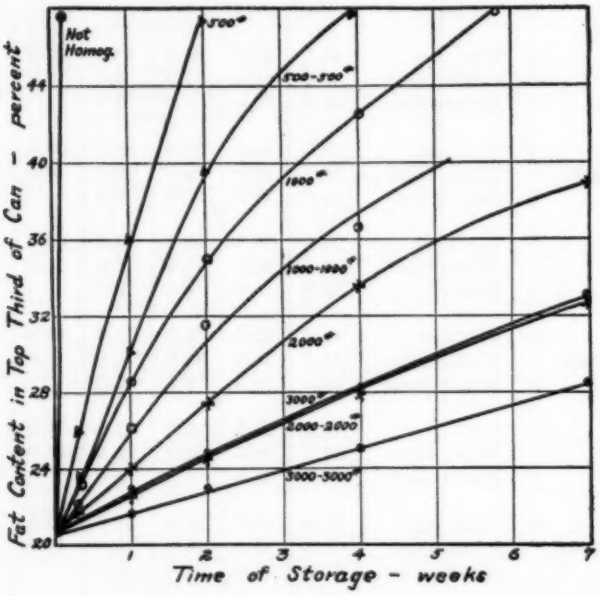

FIG. 7. SHOWING THE EFFECT OF SINGLE AND DOUBLE HOMOGENIZATION OF 20.5 PER CENT CREAM UPON THE RATE OF RISE OF THE FAT DURING STORAGE

zation retard fat separation somewhat in proportion to the pressure used. A second homogenization at the same pressure as the first further retards the rise of fat over that in cream which received the single stage treatment. Increasingly long periods of undisturbed storage cause increases in fat separation.

The effect of rehomogenization upon the viscosity, heat stability, and rate of rise of the fat in a cream of 20.5 per cent butter-

fat is the effect reproduced in table 3. The values were all obtained upon the same cream and are therefore free from differences which often occur in various lots of cream. The homogenization temperature was 80°C. (176°F.) and the temperature of storage 23°C. (73.4°F.). The heat stability and relative viscosity data were obtained within five hours after homogenization.

TABLE 3

Effect of rehomogenization upon the viscosity, heat stability, and rate of rise of the fat on cream of 20.5 per cent butterfat

Temperature of homogenization, 80°C.

HOMOGENIZATION PRESSURE	RELATIVE VISCOSITY AT 20°C. (WATER = 1)	TIME OF COAGULATION AT 120°C.	DISTRIBUTION OF FAT IN CAN AFTER TWO MONTH'S STORAGE		
			Top layer	Middle layer	Lower layer
pounds per square inch		*minutes*	*per cent*	*per cent*	*per cent*
0	3.75	168	62.5	0.9	0.2
500-0	3.80	117			
1000-0	4.20	106	51.5	7.0	0.6
1000-500	4.19	110	50.0	8.0	1.4
1000-1000	4.37	99			
1000-2000	4.82	75	40.5	16.0	6.5
1000-3000	5.55	46	33.0	18.5	8.4
2000-0	5.12	76	44.0	14.0	4.2
2000-500	4.75	81	43.0	15.0	5.5
2000-1000	4.87	75	39.5	15.5	7.5
2000-2000	5.12	55	35.0	15.5	9.0
2000-3000	5.85	30	31.5	19.5	11.0
3000-0	7.75	38	33.5	18.5	10.0
3000-500	5.50	47	34.5	19.5	9.5
3000-1000	5.70	43	33.5	19.0	9.5
3000-2000	5.80	38			
3000-3000	6.62	18	27.5	19.5	15.0

The data in table 3 summarizes the important stability changes which homogenization causes in cream. The close inverse relationship between viscosity and heat stability at various pressures stands out clearly. Rehomogenization at 500 pounds decreased viscosity and increased stability over single homogenization at

1000, 2000, and 3000 pounds. Increases above 500 pounds in the pressure used on the second stage increased the viscosity of the cream in the same manner as it decreased heat stability.

It is interesting to note that the separation of the fat decreases in the rehomogenized cream as the total pressure of both stages increases. A second pressure of 500 pounds makes little difference in fat separation, but rise of the fat is noticeably retarded when rehomogenization pressures of 1000 pounds or above are used.

Color and flavor of sterilized cream

In a previous report (16) the flavor of sterile cream observed after long periods of storage in glass containers was found much superior to the same product preserved in tins. Further observations have been made contrasting the flavor of 20 per cent sterile cream put up in glass, in plain tins and in two types of lacquered tins. After three months' storage, 25 of these samples were examined. Two cans were off flavor, but the remaining 20 did not appreciably differ in flavor from the 3 samples put up in glass. It would appear then, that sterile cream can be satisfactorily packaged either in glass, in lacquered or in plain tins, glass being perhaps the most suitable container.

A mixed group of 35 sterile cream samples which had been in storage at room temperature for from three to four and a half years were examined. Three were spoiled, while the others were still edible but had an old and disagreeable flavor.

The contrast in color between these creams when held in glass and when held in cans was interesting to note. The samples stored in glass darkened in color in a manner similar to the change noted during prolonged heating of the product. This change in color is a result of a change in the three color attributes, hue, brilliance, and chroma (18). The color observed in the creams held in tins had a greenish tinge, similar to that noted in cans of evaporated milk after prolonged storage. This change is due to an increase in chroma alone. The characteristic color of cream and evaporated milk stored in cans for long periods seems then to be dependent upon the presence of the tin.

DISCUSSION

From the work of several investigators (8) (14) (17), it is safe to assume that the clumping of the fat in homogenized cream is the cause of a lowered stability toward heat. Coagulation of such a hydrophilic colloid as casein depends upon the destruction of its water holding capacity and upon the flocculation of the denatured particles. The effect of numerous large clumps in cream may be of significance in the flocculation process. The size of the micelles and the velocity of their motion are factors which govern flocculation. Fat clumps in cream might easily provide suitable nuclei with an effect in proportion to their size, around which flocculation could proceed. On the basis of our present limited knowledge of the changes occurring during homogenization, the hypothesis that fat clumping is a major cause in lowering the stability of homogenized creams seems at this time to be correct.

It has been shown that homogenization affects the time of rennet and of heat coagulation in much the same manner. The lowered resistance of homogenized cream toward rennet coagulation may be due to any of the several changes which result from this treatment. The lowered pH (7), the increased size of the fat clumps, or the changed equilibrium arising from the heavy adsorption of protein onto the fat may affect the action of rennet on the cream.

The data plotted in figure 2 show the variation in heat stability with solids-not-fat in a 20 per cent cream, homogenized and unhomogenized. An increase in the concentration of milk-solids-not-fat greatly decreases the coagulation time of both the untreated and the homogenized creams. It will be noticed that as the solids content increases, the stability of the homogenized sample tends to approach the stability of the untreated product. This behavior is in accordance with the work of Doan (5) who showed that a critical ratio existed between serum solids and fat which controlled the degree of clumping during homogenization. In general, an increase in fat or a decrease in solids favored clumping. The low solids creams are clumped more as a result of

homogenization than those of high solids content and their stability accordingly is lower in relation to the same unhomogenized creams than those samples containing a high percentage of serum solids. Hence the two curves tend to approach one another with increasing percentages of solids.

Optimum stability upon rehomogenization was found to be obtained when a pressure of 500 pounds was used. Use of a pressure lower than 500 pounds on the second stage was not investigated, although it is possible that stability might be further increased by such treatment. A second homogenization pressure of 1000 pounds increased the stability of high fat creams over the single stage treatment, but pressures of 2000 pounds or above always decreased the heat stability of the creams of each fat percentage used.

If the assumption is made that the degree of clumping in a cream is related to its heat stability, the data in figures 4, 5, and 6, would show the relative clumping tendency in rehomogenized creams. It appears probable that rehomogenization of cream of 20 to 30 per cent fat at pressures below 1000 pounds has a destructive effect upon fat clumps. In cream so treated the fat rises slower than the fat in cream homogenized only once. However, use of a rehomogenization pressure of 2000 to 3000 pounds decreases stability and might, therefore, be expected to increase the degree of fat clumping. But the fat in cream so treated also rises proportionally more slowly as the pressure of the second homogenization is increased.

It has been clearly demonstrated by Troy and Sharp (15) that the rate of gravity creaming of milk is chiefly dependent upon the fat forming into clusters. If rehomogenization of cream at high pressures further retards the rate of rise of the fat it can only be concluded on the basis of the work of Troy and Sharp that the individual fat aggregates have been decreased in size.

Babcock's (1) photomicrographs show that increases in homogenization pressure decrease the size but increase the number and density of the fat clumps. Rehomogenization appears to have a similar effect. A decrease in the total volume occupied by the clumps due to an increase in the initial pressure or to rehomogeni-

zation would account for the slower separation of the fat encountered under such conditions. Since the smaller-sized, tightly packed clumps outnumber the larger ones obtained at low pressures, more rapid heat coagulation should follow when high pressures of homogenization have been used.

Application of some of these results to the manufacture of sterile cream is of interest. The higher the pressure of homogenization which can be used without endangering the heat stability of the cream, the less fat will separate during storage. Under the conditions used in this work, preheating to 80°C. (176°F.) and homogenizing at 3000–500 pounds gave a sufficient margin of safety to allow proper sterilization in a cream of 20 per cent fat. The second homogenization at 500 pounds pressure is decidedly beneficial in increasing heat stability. Some fat separation will occur in this product but the fat layer is soft and readily disintegrates with a little shaking or stirring. The efficiency of homogenizers will vary as will also the properties of cream from different sources. The principles derived from the data reported here should be applicable under other operating conditions, but the actual stability figures will not be the same when different material and equipment are used.

SUMMARY

1. Homogenization of cream decreases its stability toward coagulation by heat and by rennet. Differences in homogenization temperature and pressure effect the time of coagulation by either heat or rennet in a similar manner.

2. Double homogenization at 80°C. (176°F.) when the second pressure is in the vicinity of 500 pounds per square inch is beneficial in increasing the heat stability of creams containing more than 15 per cent butterfat. Use of a pressure in excess of 2000 pounds during rehomogenization decreases the heat stability of a cream below that which is characterized by single stage treatment.

3. After several months' undisturbed storage noticeable butterfat separation occurs in sterilized sweet cream homogenized at pressures as high as 4000 pounds. Increasing pressures of homog-

enization retard the rate of rise of the fat approximately in proportion to the pressure used. The fat in cream which is rehomogenized separates to a lesser extent than the fat in cream which is homogenized only once.

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THE RELATION OF FEATHERING AND HEAT STABILITY OF CREAM TO FAT CLUMPING PRODUCED BY HOMOGENIZATION*

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The work reported in this paper deals with an investigation undertaken in an effort to determine whether there is a relationship between the degree of fat clumping in homogenized cream and the stability of such cream toward heat. This stability is of considerable importance to the milk dealer selling homogenized table cream and to the manufacturer of sterilized cream. Cream having poor stability toward heat will "feather" or curdle when added to coffee or when coffee is added to it. This condition is extremely objectionable and often leads to considerable difficulty with customers. In the production of sterilized cream, a high degree of stability is essential, otherwise it is practically impossible to use sufficient heat to render the product sterile without producing a graininess or coagulation. Webb (1) has recently shown that a minimum of 2500 pounds homogenizing pressure is necessary to prevent objectionable cream separation in this product and even under these conditions a slight, soft, cream layer is often present after a few months of storage. Pressures as high as 2500 pounds usually render even the best of cream comparatively unstable.

The "feathering" of homogenized table cream and the coagulation of sterilized cream are both regarded as a heat coagulation of the casein similar to that often encountered in the processing of evaporated milk. That there is a difference, however, in the

* Publication authorized by the Director of the Pennsylvania Agricultural Experiment Station as Technical Paper No. 522. Preliminary report on this subject was made before the manufacturing section of the American Dairy Science Association at the annual meeting, Ames, Iowa, June, 1930. Received for publication April 17, 1931.

factors influencing heat coagulation in homogenized cream and in evaporated milk is illustrated by the fact that homogenization of cream greatly lowers the heat coagulation point (1) whereas homogenization of evaporated milk, even at high pressures, does not very materially affect the stability (2) (3).

Webb and Holm (4) have shown that the stability of cream toward heat is greatly altered by the degree of preheating and by the pressure of homogenization and have indicated a very definite reciprocal relationship between stability and viscosity for a given cream when heat treatment and homogenizing pressure are varied.

Tracy and Ruehe (5), in studying a case of cream "feathering," found that adjustment of the "salt balance" after the method suggested by Sommer and Hart (6) for evaporated milk, materially improved the resistance of homogenized cream toward "feathering" in coffee. The salt used to increase stability was sodium citrate but it was indicated that di-sodium phosphate and sodium bicarbonate would also act in like fashion.

In a recent report (7) these authors conclude that, "any treatment of the cream that causes the fat to clump or causes an increase in viscosity, tends to increase feathering." They state however that fat clustering is not the sole explanation since whipped cream which contains clusters, feathers to a lesser extent than the cream prior to whipping. The last statement, of course, is open to the criticism that the type of fat aggregates formed by whipping cream is entierly dissimilar to that obtained from homogenization.

After considering the experimental work mentioned, together with that of several others (8) (9) (10) (11) (12) (13), one interesting fact stands out. Practically all the methods, used or suggested for improving the stability of homogenized cream, decrease the tendency toward fat-clumping. It was therefore felt that the fat clumps themselves might play some positive rôle in inducing "feathering" and coagulation. To summarize briefly, the evidence in the literature on which this idea is based, the following facts relative to the stability of homogenized cream and the fat clumping therein, can be listed:

1. Increasing homogenizing pressures destabilizes cream toward heat. Such treatment likewise increases the degree of fat clumping.
2. Preheating cream at low temperatures [145°F. (62.8°C.) for thirty minutes or flash up to 170°F. (76.6°C.)], destabilizes the product toward heat, compared with higher heats or longer exposure. Such preheating will favor a higher degree of fat clumping than the more severe heat treatments.
3. Additions of soluble calcium salts or the use of hard water in coffee-making, increase feathering. Soluble calcium also promotes fat clumping when added before homogenizing.
4. Increases in the viscosity of cream are attributed generally to an increase in the degree of fat clumping and stability becomes less as viscosity increases.
5. Heating cream or milk after homogenization, and after the fat clumps have formed, does not materially change the degree of fat clumping (unless agitation is drastic) nor does it affect the stability nearly as much as heating prior to homogenization.
6. Additions of sodium citrate to cream prior to homogenization stabilize the product toward feathering in coffee and lessens the extent of fat clumping.
7. Increasing pressures of homogenization affect the fat clumping of evaporated milk practically not at all, and the stability but slightly, the reason for this being that the plasma-solids/-fat ratio is great enough to prevent noticeable clumping at any pressure.

EXPERIMENTAL

If there is a relationship between the degree of fat clumping and the stability of homogenized cream, any method of destroying the fat clumps or preventing their formation should result in a product which is more stable.

Mechanical destruction of fat clumps

The best argument for a belief that the fat clumps themselves affect stability was found in the results of some experiments where the clumps were destroyed mechanically after they had once formed in the cream, the stability of such cream being found improved thereby. The clumps were destroyed by: first, violent

agitation; second, double homogenization; and third, the use of the two-stage valve on the homogenizer.

The stability of the samples was determined in three ways; by coagulation with alcohol, by feathering tests in boiling hot coffee, and by sterilizing trials with sealed tins at temperatures between 235°F. (112.8°C) and 242°F. (116.6°C.), the duration of heating being fifteen minutes.

The alcohol coagulation test was carried out by measuring 5-ml. portions of the sample into test tubes and determining the least amount of alcohol sufficient to produce flocculation of the protein. The dilution effect was controlled by using a sufficient amount of water in all tests to make the total addition of alcohol plus water equal to 10 ml. This test has been found to correlate fairly accurately with other heat stability tests.

Feathering tests in coffee were performed by adding 3 drops of the sample of cream to 10 ml. of coffee (prepared from powdered soluble coffee) in a test tube, immediately after the coffee had been brought to a boil.

Sterilizing trials were made by sealing several portions of a sample in tin cans and sterilizing in a pilot sterilizer at a definite temperature for fifteen minutes. Several temperatures were used in each experiment until a trial produced a series of samples which properly indicated the difference in stability. In other words, if all the samples in the first trial were coagulated, the temperature was reduced in the next trial; or if all were smooth and uncoagulated in the first trial, the temperature was increased until a trial produced a series of cans which properly indicated the comparative resistance of the samples to coagulation.

Table 1 shows the results of one typical experiment out of many that were performed. Portion (a) of the table shows the effect of agitation, of a vigorous type, in destroying the fat clumps and increasing the resistance of homogenized cream to coagulation. The samples are comparable with each other but not with those in portions (b) or (c) since each portion represents a different original lot of cream.

The degree of fat clumping is rated descriptively and also numerically, a rating of 6 being about as much clumping as it is possible to obtain with 20 per cent cream under any circumstance.

TABLE 1

Effect of destruction of fat clumps on the stability of homogenized 20 per cent cream, forewarmed and homogenized at 150°F. (65.5°C.) for thirty minutes

TREATMENT OF SAMPLE	DEGREE OF FAT CLUMPING	ALCOHOL NUMBER	VISCOSITY AFTER HOMOGENIZING	DEGREE OF FEATHERING IN COFFEE*	DEGREE COAGULATED AFTER STERILIZING
a. Vigorous agitation					
					STERILIZED (235°F.) (110°C.)
1. Unprocessed	None (0)	6.8	38	−	− (Thin)
2. Homogenized 1000 pounds	Evident (1)	5.0	192	+	− (Medium)
3. Homogenized 3000 pounds	Very prominent (4)	4.0	625	++++	+
4. Lot 2 vigorously agitated	Evident (1)	5.2	103	±	− (Medium)
5. Lot 3 vigorously agitated	Prominent (3)	4.0	411	+++	− (Very heavy)
b. Double homogenization					
					STERILIZED (242°F.) (116.6°C.)
1. Unprocessed	None (0)	7.6	24	−	− (Thin)
2. Homogenized 1000 pounds	Very evident (2)	6.0	213	−	+
3. Homogenized 3000 pounds	Pronounced (5)	5.2	724	++++	++++
4. Lot 2 re-run at 1000 pounds	Not evident (0)	6.8	86	−	− (Medium)
5. Lot 3 re-run at 1000 pounds	Barely evident (1)	6.6	109	±	− (Heavy)
c. Two-stage valve					
					STERILIZED (239°F.) (115°C.)
1. Unprocessed	None (0)	7.2	33	−	− (Thin)
2. Homogenized 1000 pounds	Evident (1)	6.4	174	+	+
3. Homogenized 3000 pounds	Very prominent (4)	5.6	846	++++	++++
4. Homogenized 1000–500 pounds	Not evident (0)	7.0	67	−	− (Medium)
5. 3000–1000 pounds	Evident (1)	6.6	127	+	± (Very heavy)

The vicosity ratings are relative only and were obtained using a MacMichael Viscosimeter with a No. 32 wire at 60°F. (15.5°C.).

The unprocessed lots of cream were preheated at 150°F. (65.5°C.) for thirty minutes and then divided into five portions and treated as indicated. The samples described as vigorously agitated were stirred for a definite length of time with a high speed device which excluded air. All lots were cooled immediately in ice water and tests made within four hours.

It will be noted that in all cases destruction of the clumped formation of the fat resulted in an increased stability. Where the clumps were totally destroyed, the samples practically regained the resistance to coagulation which they exhibited before they were homogenized. This appears to be good evidence that the fat clumps themselves are mainly responsible for the loss of stability caused by homogenizing cream.

Increasing solids

In a previous study (9), it was found that fat clumping could be diminished by increasing the proportion of plasma solids in cream prior to processing. Thinking that an addition of solids, in the form of plain condensed skimmilk or skimmilk powder, to cream prior to homogenization, might increase its stability toward heat, a series of studies was made on this point. The evidence is not as clear cut as might be desired but it is quite definitely shown by the study reported in Table 2 that where samples of cream are greatly destabilized due to homogenization, extra solids present, if not in excess, prevent excessive clumping and do tend to stabilize the product. The opposite effect is also indicated, namely, that a lowering of the plasma solids concentration increases the degree of fat clumping and causes a loss of stability. In the case of added solids, it seems that stability is improved only in cases where homogenization has destabilized to such an extent, that the reduction of clumping (accomplished through the addition of solids) has a more beneficial effect than the solids themselves have a detrimental effect. The beneficial effect of added solids was not found to be nearly so effective as dual homogenization and where this method of homogenization is used, added solids always cause a loss of stability in fresh cream.

In the experiment illustrated by table 2, skimmilk powder was used as a source of added solids. Microscopic examination of the

TABLE 2

Effect of added solids in preventing fat clumping on the stability of 30 per cent cream forewarmed and homogenized at 150°F. (65.5°C.) for thirty minutes

TREATMENT OF SAMPLE	DEGREE OF FAT CLUMPING	ALCOHOL NUMBER	VISCOSITY AFTER HOMOGENIZING	DEGREE OF FEATHERING IN COFFEE	DEGREE COAGULATED AFTER STERILIZING (235°F.) (110°C.)
a. Normal plasma solids					
1. Homogenized 1000 pounds	Evident (1)	5.6	198	+	+
2. Homogenized 3000 pounds	Very prominent (4)	4.8	575	++++	++++
3. Homogenized 3000–1000 pounds	Barely evident (1)	5.8	56	−	− (Medium)
b. Plasma solids raised to 9 per cent (same basic cream)					
4. Homogenized 1000 pounds	Not evident (0)	6.2	183	−	− (Heavy)
5. Homogenized 3000 pounds	Evident (1)	6.0	528	+++	++
6. Homogenized 3000–1000 pounds	Not evident (0)	6.6	62	±	− (Medium)
c. Plasma solids raised to 11 per cent (same basic cream)					
7. Homogenized 1000 pounds	Not evident (0)	5.4	434	+++	++++
8. Homogenized 3000 pounds	Barely evident (1)	5.0	1,022	++++	++++
9. Homogenized 3000–1000 pounds	Not evident (0)	5.2	122	++	+++
d. Plasma solids lowered to 4.5 per cent (same basic cream)					
10. Homogenized 1000 pounds	Prominent (3)	5.2	178	++	+
11. Homogenized 3000 pounds	Very prominent (4)	4.8	321	++++	+++
12. Homogenized 3000–1000 pounds	Prominent (3)	5.4	206	+	+

samples revealed the effectiveness of the extra solids in reducing clumping and the withdrawing of solids in increasing clumping. It will be noted that stability values obtained by the three methods do not correlate exactly but in a large number of trials the variations were not great nor considered important. A critical examination of the table also shows clearly that there are two opposing factors operating in this experiment, one being the beneficial influence of a decrease in clumping; the other a detrimental influence due to an increasing amount of plasma solids.

TABLE 3

Effect of temperature of preheating and temperature of homogenizing on the degree of fat clumping and the stability of 20 per cent cream

SAMPLE HOMOGENIZED AT	DEGREE OF FAT-CLUMPING	ALCOHOL NUMBER	DEGREE OF FEATHERING IN COPPER	DEGREE COAGULATED AFTER STERILIZING (240°F.) (115.5°C.)
a. Pasteurized 145°F. (62.8°C.) for thirty minutes				
145°F. (62.8°C.)	Very evident (2)	7.4	+	+
100°F. (37.7°C.)	Pronounced (5)	7.0	+	+
80°F. (26.6°C.)	Very pronounced (6)	6.8	++++	++
b. Pasteurized 160°F. (71.1°C.) for thirty minutes (same basic cream)				
160°F. (71.1°C.)	Evident (1)	7.6	−	− (Medium)
120°F. (48.8°C.)	Prominent (3)	7.6	−	− (Heavy)
80°F. (26.6°C.)	Very prominent (4)	7.4	+	++
c. Pasteurized 180°F. (82.2°C.) for five minutes (same basic cream)				
180°F. (82.2°C.)	Very evident (2)	7.2	±	±
130°F. (53.3°C.)	Prominent (4)	7.2	+	+
80°F. (26.6°C.)	Very pronounced (6)	6.6	++++	+++

Temperature effects

Much importance has been attached to the temperature of pasteurizing or preheating of cream from the standpoint of preventing an excessive loss of stability upon homogenizing (3). While it is a fact that the heat treatment prior to processing is very important, results obtained in these experiments indicate that the temperature of homogenizing is not to be overlooked.

Where cream is preheated at high temperatures and homogenized at low temperatures, the stability is only a little better than if preheated to a low temperature. Table 3 illustrates typical results obtained when cream is homogenized at various temperatures after being preheated at 145°F. (62.6°C.) for thirty minutes, 160°F. (71.1°C.) for thirty minutes and 180°F. (82.2°C.) for five minutes. It will be noted that the data are in general agreement with the findings of Webb and Holm (3) in that stability is at a maximum under a preheating treatment of about 160°F. (71.1°C.) for thirty minutes and falls when the degree of heat used increases over this amount. If the increased stability of preheated homogenized cream depended primarily on a precipitation of calcium and albumin, the higher heats should stabilize even more effectively than the 160°F. (71.1°C.) treatment (as in evaporated milk they do) but this is not found to be the case with homogenized cream. Stability parallels more nearly the degree of fat clumping than the temperature of preheating. If the heat effect alone, were the factor, homogenizing at high or low temperature after the preheating should make little difference in stability whereas actually, lowering the temperature prior to homogenization increases fat clumping and decreases stability.

Salt stabilizers

Previous investigators (5) have shown that buffer salts such as sodium citrate, di-sodium phosphate, sodium bicarbonate, etc., will render homogenized cream more stable and have attributed this effect to a change in the so-called "salt balance" whereby the normal excess of calcium is compensated by citrate, acid phosphate or acid carbonate ions. Experiments, carried out on homogenized cream using stabilizers seem to indicate that the beneficial effects may be due to the fact that these stabilizers tend to restrict clumping of the fat as well as to their ability to change the "salt balance." Some of the benefit may also be due to the action of these salts in reducing the hydrogen ion concentration of the cream. In any case, where the stabilizer is added after homogenization, the increase in stability is not nearly so marked as where the salts are added prior to homogenizing. Table

4 shows the data obtained in a trial using sodium citrate. Essentially the same results were obtained with other so-called salt stabilizers. It will be noted that two-stage homogenization had considerably more effect in increasing the stability of the cream homogenized at 3000 pounds than did the addition of the citrate

TABLE 4

Effect of sodium citrate added at different stages of processing on the fat clumping and the stability of 20 per cent cream, preheated and homogenized at 150°F. (65.5°C.) for thirty minutes

TREATMENT OF SAMPLE	DEGREE OF FAT CLUMPING	ALCOHOL NUMBER	VISCOSITY AFTER HOMOGENIZING	DEGREE OF FEATHERING IN COFFEE	DEGREE COAGULATED AFTER STERILIZING (240°F.) (115.5°C.)
Normal cream					
1. Homogenized 3000 pounds	Prominent (3)	5.0	430	+++	+++
2. Homogenized 3000–1000 pounds	Not evident (0)	5.6	81	–	– (Medium)
0.10 per cent sodium citrate added after homogenizing (same basic cream)					
3. Homogenized 3000 pounds	Prominent (3)	5.6	392	++	+
4. Homogenized 3000–1000 pounds	Not evident (0)	6.0	74	–	– (Thin)
0.10 per cent sodium citrate added before homogenizing (same basic cream)					
5. Homogenized 3000 pounds	Barely evident (1)	7.2	218	–	– (Thin)
6. Homogenized 3000–1000 pounds	Not evident (0)	7.4	60	–	– (Very thin)

after homogenizing. The degree of fat clumping is not changed apparently by citrate addition where such addition is made after homogenization and the stability is not affected greatly. Where citrate was added prior to homogenizing the stability was greatly improved but the degree of fat clumping was at the same time considerably diminished as evidenced by microscopic examination and by viscosity readings.

SUMMARY AND CONCLUSIONS

The experimental work described indicates that the degree of fat clumping in normal, sweet, homogenized cream is probably the most important single factor affecting the stability of such cream toward heat. The fact that mechanical destruction of the fat clumps improves stability would seem to preclude the possibility that both fat-clumping and stability are influenced by a third factor and to show that the relationship is one of direct cause and effect. Other evidence in the literature of the subject also tends to confirm this opinion but not so unanswerably as the fact that the cream is comparatively unstable when clumps are present and stable when they are destroyed.

As to the manner in which the fat clumps lower the heat coagulation point of cream, a physical property heretofore ascribed entirely to the condition of the casein and the properties of the serum, it is not felt that enough evidence is at hand to formulate a theory. However it is believed that the fat clumps act as a structure on which the casein coagulates more readily than it would otherwise. Perhaps the action is accelerated by the fact that the casein adsorbed on the fat globules, having lost its mobility and according to some concepts of adsorption, its hydration, is thereby rendered more susceptible to agents of coagulation. If this is true, then fat clumps bring a large proportion of such easily precipitated casein into intimate contact and presumably would favor coagulation. Naturally the subject is a complicated one and it is very difficult to reconcile all the demonstrable facts with any theory. As a result of this study, however, a few definite statements can be made relative to the production of sterile cream and homogenized table cream of high stability.

Double homogenization or the use of a two-stage valve is very effective in improving the stability of cream compared with a single processing treatment and constitutes a better method, perhaps, than the addition of salt stabilizers although in some cases both treatments may be necessary. Dual homogenization makes it possible to use a much higher total pressure and thus to obtain better homogenizing efficiency, which is important, par-

ticularly in the manufacture of sterile cream. Naturally, dual or two-stage homogenization will reduce the viscosity of the cream, a result not particularly favored for table cream, but less objectionable than cream producing flakes in coffee.

Under some conditions, additions of milk solids in the form of high quality condensed skimmilk or skimmilk powder will raise the heat coagulation point of homogenized cream. Excessive additions to any cream or any addition to some creams may cause loss of stability, however.

The temperature of homogenization as well as the temperature of preheating is important in preserving the stability of homogenized cream. In general the cream should not be homogenized at a temperature lower than that at which it is preheated unless this is over 170°F. (76.6°C.) for 30 minutes or 180°F. (82.2°C.) flash.

Salt stabilizers used for improving the stability of homogenized cream toward heat should be added prior to homogenization for maximum results, since they not only stabilize by correcting the "salt balance" but also quite as much, perhaps, by hindering the formation of fat clumps during homogenization.

As a general rule, the heat coagulation point of sterile cream and the tendency of homogenized table cream to feather in coffee, parallels the degree of fat clumping but in an inverse fashion.

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PROCEEDINGS OF THE TWENTY-SIXTH ANNUAL MEETING OF THE AMERICAN DAIRY SCIENCE ASSOCIATION

The twenty-sixth Annual Meeting of the American Dairy Science Association was held at the College of Agriculture, University of California, Berkeley and Davis, California, July 13 to 15. This is the first time that a meeting of the Association has been held on the Pacific Cost. The attendance was very satisfactory there being approximately 150 representatives of the industry present from all sections of the United States and several provinces of Canada.

A number of members and their families took advantage of the itinerary arranged for those who came by way of Southern California. On July 7 as guests of the Los Angeles Chamber of Commerce they made a tour of moving picture studios and many other points of interest in and around Los Angeles. They were luncheon guests of the Los Angeles Milk Distributors at Casa del Mar Club, Santa Monica.

On July 8 as guests of the Southern California Milk Dealers' Association they visited other points of interest in Los Angeles, Pasadena and the San Fernando Valley. The Challenge Creamery and Butter Association at Los Angeles and the Arden's Certified Dairy at El Monte were visited during the morning and at noon lunch was served by the Adohr Stock Farms, Van Nuys.

On July 9 an auto caravan, which included free transportation furnished by the Dairy Plant Operators of the San Joaquin Valley, made the trip from Merced to the Yosemite Valley. The following morning the party left Yosemite for San Francisco. At noon they were served lunch as guests of the Golden State Company, Ltd. After lunch the milk powder and sweet cream plant of this company at Los Banos was visited.

During the morning of July 11 transportation was furnished by the San Francisco Milk Distributors for a trip to Stanford University and Millbrae Dairy. After inspecting this herd lunch

was served on the Mills Estate by the Millbrae Dairy. In the afternoon there was instruction in judging dairy products at the San Francisco plant of the Golden State Company, Ltd.

On Monday morning, July 13, the group ferried across to Oakland and after a tour of the University of California campus settled down to the official program which started at Berkeley and was continued at Davis during the next two days.

During the formal meetings at Davis on July 14 and 15 the ladies were given a special two day trip through the Sierra Nevada Mountains to Lake Tahoe and return.

Those in attendance were enthusiastic in their praise of Dr. Roadhouse and his associates for the completeness of their arrangements for the comfort and entertainment of the visitors.

The following program was presented:

July 13, 1931, University of California Campus, Berkeley

9:30 Tour of University of California Campus, Berkeley—G. E. Gordon in charge.

International House

12:00 Cafeteria Luncheon.

12:45 Address: Influence of International House on University Life—A. C. Blaisdell—Auditorium, International House.

Giannini Hall

1:45 Address of Welcome: C. B. Hutchison, Dean, College of Agriculture.

2:15 Address: The Dairy Extension Program in California—B. H. Crocheron, Director, Agricultural Extension.

University Farm, Davis

8:00 Registration: Auditorium, Class Room Building.

GENERAL SESSION

University Farm, Davis, Tuesday, July 14, 1931—Auditorium, Class Room Building

H. B. ELLENBERGER, President, presiding

8:30 Call to order.
Address of Welcome—W. I. Howard, Director, Branch College of Agriculture, Davis.

8:45 President's Address—H. B. Ellenberger, University of Vermont Announcements.

9:45 The Inorganic Phosphorus Content of the Blood Plasma as an Indication of Phosphorus Deficiency in Cattle—C. H. Eckles, L. S. Palmer, T. W. Gullickson, University of Minnesota.

10:00 Salt Sick—A Naturally Occurring Nutritional Anemia in Cattle—W. M. Neal, University of Florida.
10:15 The Present Dairy Situation—H. R. Tolley, University of California.
10:30 The Application of Science to Marketing Dairy Products—Sam H. Greene, California Dairy Council.
10:45 Calcium and Phosphorus Balances with Milking Cows through Full Lactation Periods—H. B. Ellenberger, J. A. Newlander, C. H. Jones, University of Vermont.
11:00 The Ability of Dairy Cows to Withstand Exposure to Cold Weather—J. R. Dice, North Dakota Agricultural College.
11:15 Some Studies in the Physiology of Fats—H. M. Evans, S. Lepkovsky, University of California.
11:30 Problems of Undulant Fever in the West—Karl F. Meyer, Director, Hooper Foundation Medical Research, San Francisco.
11:45 Some Effects of Variations in Temperature and Humidity on the Dairy Cow—W. M. Regan, G. A. Richardson, University of California.
12:00 Buffet Luncheon—Dairy Industry Building, Room 205.

DAIRY PRODUCTION[1]

Tuesday, 1:30 p.m.—Room 147, Animal Science

P. M. BRANDT, Chairman, Dairy Production Section, presiding

1:30 Gestation Period of Holstein Cattle—J. C. Knott, Washington State College.
1:45 Dry Skim Milk Rations vs. Blood Flour Rations for Calf Raising—S. I. Bechdel, Pennsylvania State College.
2:00 Experiments Regarding the Drying Up of Cows—Ralph Wayne, University of Minnesota.
2:15 Experiments Regarding the Use of Rye as a Feed for Dairy Cattle—Henry Hirst, University of Minnesota.
2:30 Mangels versus Silage for Milking Cows—Earl Weaver, A. H. Kuhlman, Oklahoma Agricultural College.
2:45 The Influence of Fat and Curd Tension upon the Digestibility of Milk for Calves—C. Y. Cannon, Iowa State College.
3:00 The Physiological Effect of Rations Restricted Principally or Solely to the Alfalfa Plant—J. R. Haag, Oregon State Agricultural College.
3:15 Proper Recognition for Production Records in our Dairy Shows—C. E. Wylie, University of Tennessee.
3:30 Blood Volume Determination in the Live Dairy Cow and its Significance—H. A. Herman, C. W. Turner, University of Missouri.
3:45 The Influence of the Number of Daily Milkings upon Production of Dairy Cows—R. F. Morgan, H. P. Davis, University of Nebraska.
4:00 A Visit to the Dairy Barn and Inspection of Specialized Apparatus in Animal Science Building.

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[1] Concurrent with this Program, Roy C. Jones, Bureau of Dairy Industry, U. S. D. A., will give an Herediscope Demonstration especially designed for Dairy Extension Workers—Animal Science, Room 151.

DAIRY MANUFACTURES

Tuesday, 1:30 p.m.—Auditorium, Class Room Building

C. L. ROADHOUSE, Chairman, Dairy Manufactures Section, presiding

1:30 Pasteurization and Cooling of Milk in a Vat to Secure Optimum Creaming —J. C. Marquardt, A. C. Dahlberg, New York Experiment Station.

1:45 A Study of the Quality of Butter Made from Refrigerated Cream Held on Farms for Twice Weekly Shipments—G. Wilster, Oregon State Agricultural College.

2:00 The Heat Coagulation of Milk from Individual Cows during a Lactation Period—B. H. Webb, E. F. Deysher, G. E. Holm, Bureau of Dairy Industry, U. S. D. A.

2:15 Simplified Test for the Detection of Neutralized Cream—J. I. Keith, Oklahoma Agricultural College.

2:30 Protein Decomposition Studies in Cream and Butter—H. A. Bendixen, Washington State College.

2:45 Viability of Lactobacillus Acidophilus as Affected by Freezing in a Sherbert Mixture—C. C. Prouty, Washington State College.

3:00 The Influence of the Various Monosaccharide and Diaccharide Sugars on the Crystallization Point of Lactose in Ice Cream—J. H. Erb, Ohio State University.

3:15 Manufacture and Tests of High-Quality Domestic Casein—E. O. Whittier, Bureau of Dairy Industry, U. S. D. A.

3:30 Chemical Study of Casein Made by Natural Sour Method in Eight Idaho Plants—D. R. Theophilus, H. C. Hansen, R. S. Snyder, University of Idaho.

3:45 Comparative Efficiency of Cream Collection by Cream Stations, Truck Routes and Direct Shipping—C. O. Youngstrom, D. R. Theophilus, F. W. Atkeson, University of Idaho.

4:00 A Visit to the Dairy Industry Building.

SYMPOSIUM ON EDUCATION

Tuesday, 8:00 p.m.—Auditorium, Class Room Building

H. B. ELLENBERGER, presiding

8:00 The Psychology of Learning—G. M. Ruch, University of California.

Open Discussion and Questions.

Curricula for Dairy Students.

(a) The Curriculum for Dairy Production—P. M. Brandt, Oregon State Agricultural College.

Discussion: W. M. Regan, University of California.

(b) The Curriculum for Dairy Manufactures—H. W. Nisonger, Junior Dean, Ohio State University.

Discussion: R. B. Stoltz, Ohio State University.

Organization of Instruction in Dairy Machinery—L. C. Thomsen, University of Wisconsin.

Discussion: C. L. Roadhouse, University of California.

DAIRY PRODUCTION

Wednesday, July 15, 8:30 a.m.—Room 147, Animal Science

P. M. BRANDT, Chairman, Dairy Production Section, presiding

8:30 Water Requirements of Dairy Calves—F. W. Atkeson, G. C. Anderson, T. R. Warren, University of Idaho.

8:45 The Inheritance of Hernia in Holstein Cattle—T. R. Warren, F. W. Atkeson, University of Idaho.

9:00 Irradiation of the Cow's Udder with a Quartz Mercury Lamp as a Treatment for Mastitis—H. C. Hansen, V. A. Cherrington, E. M. Gildow, F. W. Atkeson, University of Idaho.

9:15 A Mathematical Expression of the Relation of Fleshing to Skeleton and its Application to Beef and Dairy Production Researches—P. W. Gregory, H. R. Guilbert, S. W. Mead, University of California.

9:30 Pasture Studies in California—A. Folger, University of California.

9:45 Some Investigations in the Fibre Requirements of Ruminants—S. W. Mead, Harold Goss, University of California.

10:00 Measuring the Returns from Pasture with Dairy Cattle—P. M. Brandt, Oregon State Agricultural College.

10:15 Sterility and Difficult Breeding in Dairy Cattle—I. R. Jones, Oregon State Agricultural College.

10:30 The Effect of Various Mineral Supplements on Calcium Phosphorus and Nitrogen Metabolism of Dairy Cattle—J. R. Haag, Oregon State Agricultural College.

10:45 The Use of the Ovarian Hormone for Diagnosing Pregnancy in Dairy Cattle—C. W. Nibler, University of Nebraska.

11:00 Vitamin A and D Requirements of Dairy Calves—I. W. Rupel, G. Bohstedt, E. B. Hart, University of Wisconsin.

11:15 Section Meeting, Committee Reports, Business.

DAIRY PRODUCTS AND BACTERIOLOGY

Wednesday, 8:30 a.m.—Auditorium, class room building

C. L. ROADHOUSE, Chairman, Dairy Manufactures Section, presiding

8:30 An Alkaline Reagent as a Substitute for Acid in Testing Dairy Products by the Babcock Method—W. E. Petersen, University of Minnesota.

8:45 The Effect of Flash Pasteurization on the Creaming of Milk—A. C. Dahlberg, J. C. Marquardt, New York Experiment Station.

9:00 The Effect of Various Salts upon the Heat Coagulation of Milks of Different Concentrations—B. H. Webb, G. E. Holm, Bureau of Dairy Industry, U. S. D. A.

9:15 Tests of Ice Refrigerted Cooling Units under Control Conditions—R. L. Perry, University of California.

9:30 A study of Methods for Determining Numbers of Molds and Yeasts in Butter—E. G. Hood, A. H. White, Department of Agriculture, Ottawa, Canada.

9:45 Factors Influencing the Freezing Properties, Stability and Physical Properties of Chocolate Ice Cream—W. H. E. Reid, W. E. Painter, Univeristy of Missouri.
10:00 Checking the Age of Ice Cream as a Basis of Quality Control—H. F. Judkins, National Dairy Products Corporation, New York.
10:15 The Mechanical Effect upon Heat Coagulation of Fat Dispersed by Homogenization—B. H. Webb, G. E. Holm, Bureau of Dairy Industry, U. S. D. A.
10:30 A Study of the Physical and Chemical Properties of Cottage Cheese Manufactured from Skim Milk Powder—W. H. E. Reid, C. L. Fleshman, University of Missouri.
10:45 A Study in the Manufacture of Gorgonzola Type Cheese—C. A. Phillips, Fred Kopp, University of California.
11:00 Section Meeting, Committee Reports, Business.

EXTENSION SECTION

Wednesday, 8:30 a.m.—Room 151, Animal Science

M. J. REGAN, Chairman, Dairy Extension Section, presiding

8:30 How Far Can We Go in Recommending a Dairy Ration with a Minimum Grain Mixture—George B. Caine, Utah State Agricultural College.
8:45 Methods of Handling Dairy Herd Improvement Association Work in Central States—J. W. Linn, Kansas State College.
9:00 Enterprise Efficiency Studies on Dairy Farms—A. Shultis, L. W. Fluharty, University of California.
9:15 Does High Production Pay?—J. C. McDowell, Bureau of Dairy Industry, U. S. D. A.
9:30 Recent Development in Official Testing—H. N. Colman, Oregon State Agricultural College.
9:45 Quality Dairy Products—M. L. Flack, University of Nebraska.
10:00 Results of Purebred Sire Contest as Conducted in Iowa—Floyd Johnston, Iowa State College.
10:15 Breed Extension Projects as Part of the Dairy Extension Program—D. L. Fourt, University of Idaho.
10:30 Theoretical Advantages of Cooperative Bull Associations Compared with Actual Results Obtained—F. W. Atkeson, University of Idaho.
10:45 Calculating Dairy Rations—F. B. Headley, University of Nevada.
11:00 Business Meeting of Section.

GENERAL PROGRAM

Wednesday, 1:30 p.m.—Auditorium, Class Room Building

H. B. ELLENBERGER, presiding

1:30 Calcium and Phosphorus Metabolism during Pregnancy and Lactation on a Low Calcium Diet—Harold Goss, University of California.
1:45 Some Effects of Low Protein Diets on the Estrus Cycle and Reproduction in the Rat—Harold Guilbert, Harold Goss, University of California.

2:00 Activation of Impotent Males with an Ovary Stimulating Hormone—H. H. Cole, Harold Guilbert, Harold Goss, University of California.
2:15 The Effect of Feeding Concentrated Coloring Substances to Dairy Cows on the Color of Milk and Milk Fat—W. D. Swope, Pennsylvania State College.
2:30 A New Technique for Obtaining Standard Shades in Butter—E. G. Hood, A. H. White, Department of Agriculture, Ottawa, Canada.
2:45 The Source of Thermophilic Bacteria—C. S. Mudge, J. L. Henderson, University of California.
3:00 The Effect of Some Feeds on Certain Properties of Milk—G. A. Richardson, University of California.
3:15 State Grading of Milk for Dairy Manufacture by Direct Count—M. E. McDonald, State Department of Agriculture, Sacramento.
3:30 Studies in Increasing Antirachitic Potency of Cow's Milk—B. H. Thomas, Iowa State College; Florence L. MacLeod, Columbia University.
3:45 The Present Status of the Milk Sugar Problem—E. O. Whittier, Bureau of Dairy Industry, U. S. D. A.
4:00 Business Meetings of Sections.

7:00 Banquet—California Inn, University Farm Campus.

Secretary Graves reported by letter that each of the four proposals to amend the Constitution were carried by large majorities as the result of balloting by mail during the winter. As a result Article 6 now reads as follows:

ARTICLE 6. The officers of this Association shall be President, Vice-President, Secretary-Treasurer, and Journal Editor. The President and Vice-President shall be elected by vote of the general membership and the term of office shall be one year beginning January first. The Secretary-Treasurer and the Journal Editor shall be appointed by the Executive Committee and the term of office shall be at the discretion of the Committee.

"The Preisdent, Vice-President and the chairmen of the sections shall constitute the Executive Committee. In case of the absence of a chairman of a section the next ranking officer is authorized to represent the section at any meeting of the Executive Committee."

The Executive Committee met on both July 13 and 14. Those present were Ellenberger, Wylie, Brandt, Roadhouse and Gordon. There was no one present to represent the Dairy Economics section.

Action taken by the Executive Committee included the following:

The Official Testing section is to be discontinued in accordance with the decision of that section at the Ames meeting last year

and the Breeds Relation Committee is to function as a committee of the Production section.

It was voted to be the sense of the Executive Committee that the chairman and seretary of each section and division shall submit to the general secretary minutes, list of officers, and list of committees with their duties and that the general secretary shall furnish copies of this information to the new officers of the Association, its sections and divisions, and that the general secretary shall be responsible for obtaining and distributing this information.

The President was authorized to appoint a committee to act in an advisory capacity with the "Century Dairy Exhibit, Inc." of the Century of Progress Exposition to be held in Chicago.

It was voted that the Constitution of the Association as amended be published in the Journal of Dairy Science with 100 reprints for distribution to new officers as elected.

Mr. R. R. Graves was appointed to continue as Secretary-Treasurer with a salary of $200 per year.

Dr. A. C. Dahlberg was appointed to continue as Journal Editor. Because of increased responsibilities in connection with the program explained hereafter his salary was increased to $500 per year beginning July 1, 1931.

Dr. A. C. Dahlberg presented an extensive report of the committee appointed to investigate future publishing contracts for the Journal of Dairy Science. This report was also presented to the general business meeting which meeting voted to recommend it to the Executive Committee for approval. The Executive Committee voted to approve this report for a new contract for the Journal of Dairy Science subject to the final approval of the Journal Management Committee to be appointed by the President. President Ellenberger has appointed the following as members of the Journal Management Committee:

O. F. Hunziker
R. R. Graves
A. A. Borland

The President has appointed F. W. Bouska to serve in an advisory capacity with the "Century Dairy Exhibit, Inc."

In the general business session the Executive Committee was authorized to incorporate when and in such manner as may seem most desirable to the welfare of the Association and the publication of the Journal of Dairy Science.

The report of the Committee on Bacteriological Methods of Analyzing Dairy Products was received and filed.

The report of the National Dairy Improvement Committee was read and it was voted to continue this committee for another year. The members will be appointed by the President in the near future.

Professor Ragsdale of Missouri announced that arrangements had been made for headquarters at the Missouri Hotel during the National Dairy Show at St. Louis and that the banquet at which the results of the Students Judging Contest are to be announced will be held in the same hotel.

The Committee on Dairy Products Judging was authorized to arrange for a banquet at the time of the National Dairy Exposition for announcement of results of the judging contest.

A Nominating Committee consisting of P. M. Brandt, A. C. Ragsdale, R. W. Bell, W. D. Swope and J. R. Dice submitted the following report:

For President:
C. E. Wylie, Tennessee
E. L. Anthony, Michigan
For Vice-President:
R. B. Stoltz, Ohio
W. V. Price, Wisconsin

The following resolutions were presented and adopted:

"WHEREAS, our friend and fellow-worker, J. H. McClain, a pioneer in dairy extension work in this country, has been called from his earthly labors after having done so much toward the development and improvement of dairying in all parts of the United States, but more especially in his beloved Southland, WE, the members of the American Dairy Science Association, assembled in Davis, California, July 15, 1931, take this opportunity to express our sympathy to his beloved wife and son. A copy of this resolution is to be sent immediately by our Secretary to Mrs. J. H. McClain of Campebell, South Carolina.

"WHEREAS, Dr. Stephen Moulton Babcock, whose scientific discoveries and investigations have made him justly famous throughout the world, has recently been called from his earthly labors, WE, the members of the American Dairy

Science Association now assembled in Davis, California, desire to express our words of sympathy to his co-workers in the University of Wisconsin, and especially to his brother and other relatives. In losing Dr. Babcock, the world has lost a great and good man and our Dairy Industry has lost one of its greatest benefactors. While time shall last and man shall strive for improvement, the influence of our faithful friend and eminent leader shall continue and the world shall always be a better place in which to dwell because for 87 short years he lived among us.

"WHEREAS, the American Dairy Science Association through invitation of its Western Division has held its annual meeting on the Pacific Coast for the first time, and

"WHEREAS, this Western Division in cooperation with several of the Dairy Departments represented in its territory and with several other dairy organizations, particularly the California Dairy Council, have arranged so excellently for our entertainment and program.

"*Be It Resolved* that we express our appreciation to all those who have planned so carefully for our convention and especially to Dr. C. L. Roadhouse and his co-workers and to our Western Division.

Respectfully submitted,

R. B. STOLTZ,
J. C. MCDOWELL,
F. W. ATKESON,
C. Y. CANNON,
A. C. DAHLBERG."

In the Production section it was pointed out that apparently the intent of the uniform herd test rules was not understood thoroughly and that some states were not following the uniform rules in conducting the test, certain ones apparently regarding the herd test as official while others regard it as an association record. It was stated that it was the intent of the breed associations to regard the herd test as official. It was proposed that the necessity of clarifying the situation should be called to the attention of the Breeds Relation Committee.

Chairman Brandt appointed the following committees:

Committee on Evaluation of Proven Sires

H. O. Henderson, *Chairman*
F. W. Atkeson
C. W. Turner
R. R. Graves
J. L. Lush

Committee on the Standardization of Production Records

W. M. Regan, *Chairman*
M. H. Frohman
W. E. Petersen
H. P. Davis
I. R. Jones

Committee on Students' Dairy Cattle Judging Contests

J. E. Dorman, *Chairman*
I. W. Rupel
Warren Gifford
Earl Weaver
C. E. Wylie

Committee on Breeds Relations

J. B. Fitch, *Chairman*
R. T. Harris
E. L. Anthony
G. C. White
E. V. Ellington

G. Bohstedt was elected Chairman and T. W. Gullickson Secretary for the coming year.

In the Dairy Manufacturing section progress reports were submitted from the sub committees on Chemical Methods of Testing Dairy Products. These dealt with "Testing Milk and Cream for Fat" and "Testing Ice Cream for Fat."

The Committee on Judging Dairy Products was empowered to make changes in the rules governing the Students' National Dairy Products Judging Contest.

The following committee appointed by Chairman Roadhouse is to consider the question of Dairy Engineering curricula and report at next year's meeting:

H. A. Bendixen, *Chairman*
R. L. Perry
M. P. Mortensen

R. B. Stoltz was elected Chairman and E. G. Hood Secretary for the coming year.

In the Extension section M. J. Regan was elected Chairman, M. L. Flack, Vice Chairman and C. R. Gearhart Secretary for the coming year.

On July 16 the California Dairy Council provided transportation for all who desired same for a trip to Hartsook Lodge on the Redwood Highway by Williams and Lake County. The Lake County Farm Bureau provided a barbecue lunch at Buckingham Point. In the evening a program was provided by the California Dairy Council.

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JOURNAL
OF
DAIRY SCIENCE

VOLUME XIV
JANUARY, 1931, to NOVEMBER, 1931

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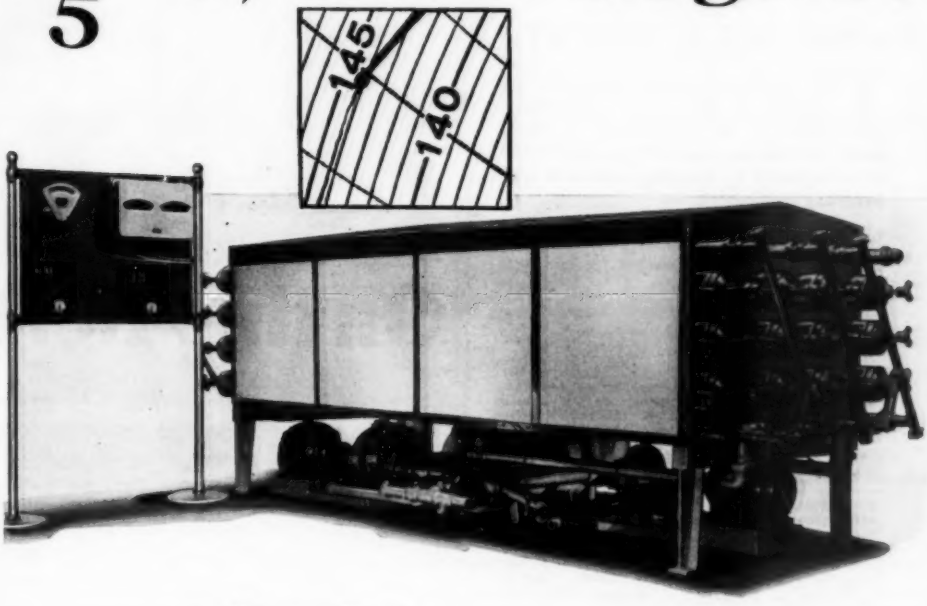

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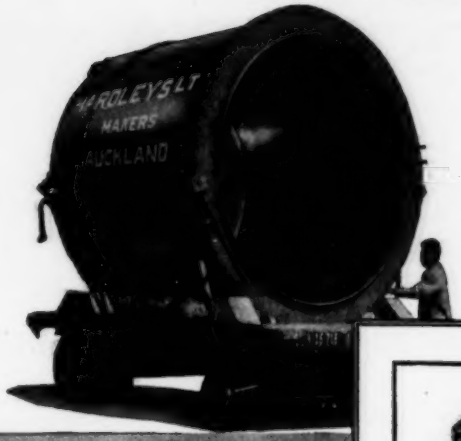

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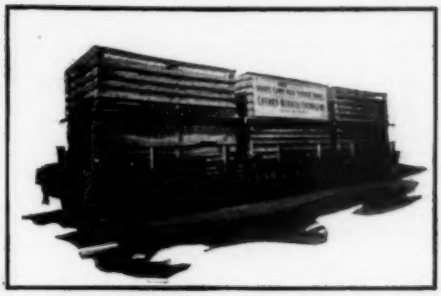

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